This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

WIDENER LIBRARY
HX HICX 1

Sci 1520.387

Harvard College Library

FROM

Transferred from
Engineering Library.

SCIENCE CENTER LIBRARY

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF

PHILADELPHIA

VOLUME XXX

EDITED BY THE PUBLICATION COMMITTEE

PHILADELPHIA

THE ENGINEERS' CLUB OF PHILADELPHIA

1913

JUN 20 1917
TRANSFERRED TO
HARVARD COLLEGE LIBRARY

Richard T. Ely

TRANSFERRED TO
HARVARD COLLEGE LIBRARY
April 2, 1925

Editors of other technical journals are invited to reprint articles from this journal, provided due credit be given the PROCEEDINGS

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XXX JANUARY, 1913. No. 1

PAPER No. 1115.

METHODS AND MEANS OF SMOKE ABATEMENT

Paper Read before the Club October 5, 1912
By MR. O. R. McBRIDE,
Pittsburgh, Pa.

The object of the investigation which is being made by the Department of Industrial Research of the University of Pittsburgh is to improve the conditions of the city. The slogan of every loyal Pittsburgher is, "Pittsburgh Promotes Progress." In line with this a citizen of Pittsburgh, without expecting any personal gain other than that which comes to every inhabitant from each improvement in the city, and seeking no glory, generously offered to finance an investigation of the smoke problem. He wished this investigation to be more thorough than any other ever made, therefore he placed the problem in the hands of the Industrial Research Laboratory of the University of Pittsburgh, together with the necessary funds for a thorough and exhaustive study of the problem. A large staff of experts has been appointed, each to make a study of the particular phase of the problem for which his experience and training fit him.

Physicians are securing data as to the effect of smoke and soot on the health of the individual who must live in a smoky atmosphere. Architects are determining in just what way and how much the presence of smoke and soot affects their work. A meteor-

ologist is studying the relation of smoke and soot and the weather, with special reference to fogs and sunshine, fogs being increased both in intensity and number, and sunshine decreased in intensity and total duration. A botanist is carrying on some special investigations into the effect of smoke and soot on plant life. Economists are making an exhaustive study of the increase in the cost of living on account of the presence of smoke and soot. A chemist and a physicist are studying the nature of smoke and soot. A lawyer is making a study of the legal side of the smoke abatement question in order that an ordinance can be drawn that will be proof against the attacks of the defendants council should it so happen that the courts need be appealed to to bring about an abatement in any particular case. We are optimistic, but not to the point where we think we can dispense with an effective legal club.

But most important of all is the study of the smoke abatement question from the engineer's standpoint. All the other work, except the lawyer's, shows the evil effects and proves that smoke is a nuisance. The engineer must answer the questions, "What can I do to eliminate the smoke from my stack?" and, "Will it pay me?" The latter question must be answered, and in the affirmative, before the first will be asked, in most cases.

Smoke is a nuisance, considered from every standpoint except one. That one is from the point of view of the manufacturer of soap and other cleaning materials. A soap manufacturer said to us, "We're in favor of smoke. The more smoke the more soap," and added, "It is purely selfish in us." He was not anxious that smoke be made in his own plant, however.

The engineer who studies the combustion problem knows that smoke is expensive to the owner of the furnace. The physician knows that certain diseases are more prevalent in a smoky atmosphere, especially pneumonia, catarrhs, colds and other afflictions of the throat, nose and lungs. The economist knows that the cost of living is increased by smoke and soot, the extra expense coming in many ways. We have heard the statement that laundry bills, bills for cleaning of all kinds, and the work for the housekeeper are all increased, called "an old woman's argument," which is simply admitting that his argument cannot be refuted.

"The city is clean to what it used to be." "Our stack does not smoke." "We are not making any smoke." These statements and

others like them are made to us time and time again, making it necessary to prove that a smoky condition exists. To prove that is easy—just observe the stacks, or look for the sky line. Also take a few pictures after returning from a clean city. We took the simplest method—observing the stacks—in which method we could put figures in our records and are proving all the time that too much smoke is being made.

In prescribing the remedy for any particular plant, we must be able to diagnose the case and to say just what is the matter. We, therefore, go into the plants and make a thorough examination of the furnaces. It is our endeavor to get as complete data from the plant as possible. We get as many dimensions of the furnace as we can, in order to be able to duplicate it if desired. We get data as to the amount of coal used, draft measurements, etc. We also notice if the plant is apparently run efficiently, whether the fires have holes in them or not and anything else that we think could affect the efficiency and smoke production. When we have as much of this data as we can get, we draw our conclusions. If the engineer or superintendent asks us for our advice we give it, otherwise we hold our peace. We have no connection with the city smoke inspector's office, and have no authority to force our opinions on any one.

Combustion is the union of the combustible substance or fuel with oxygen, accompanied by the evolution of light and heat. The available fuels consist mostly of carbon, either fixed carbon or volatile matter. Bituminous or soft coal is the principal fuel we have to deal with in Pittsburgh. The volatile matter is mostly heavy hydro-carbons, and these are distilled or driven off at a temperature much below the ignition point of carbon or of the chemical compounds of carbon and hydrogen. It is this volatile matter which is responsible for the smoke and it is this volatile matter which makes necessary the special constructions of the furnace as well as the extraordinary care on the part of the fireman if it is to be burned smokelessly and efficiently. Pittsburgh, being in the heart of the best soft coal district in the United States, will use this fuel and we must answer all questions as to how it is to be used efficiently and at the same time avoid smoke. It is fortunate for us that in general, efficiency and smokelessness go hand in hand.

The most efficient furnace is that furnace in which the losses

are reduced to a minimum and the heat gotten from the fuel is applied where it is wanted. If it is a boiler furnace you want your heat to make steam. If it is a metallurgical furnace you use it to heat the steel, iron or whatever you are working. The problem is then to reduce your losses to the lowest practicable figure.

Heat is lost in some of four ways, viz.: Imperfect combustion, sensible heat carried away by the waste gases, unburned carbon in the ash and radiation.

When carbon is completely burned or to carbon dioxide 14,500 B. T. U. are given out per pound of carbon. When it is burned to carbon monoxide only 4,450 B. T. U. are given out, or a loss of 10,050 B. T. U. for every pound of carbon burned to carbon monoxide. The U. S. Geological Survey (now the U. S. Bureau of Mines) has shown that for every one-tenth per cent. increase in carbon monoxide in the flue gases there is a decrease of two per cent. in the efficiency of a boiler plant, and that a smoky stack is an indication that carbon monoxide is present in the flue gases. They have also shown that the presence of carbon monoxide indicates the presence of unburned hydrogen and some hydro-carbons. On account of the large losses due to incomplete combustion every effort should be made to avoid this condition in the furnace. *Porter and *Ovitz give the loss when the stack is smoking from three to ten per cent. of the heat in the fuel.

If the owner of a plant should take a walk through his plant and see unburned carbon in the ash pile and on investigation found the amount of carbon was equal to the amount of ash, probably some one soon would be seeking employment elsewhere.

The higher figures given above would be more loss than if the ash pile were one-half unburned coal.

It is just as easy to have this same loss or even a greater loss and yet have no smoke. We would not think that a plant is efficient if the carbon dioxide per cent. in the flue gases falls to ten, which means that over twice as much air is passing through the furnace than is theoretically necessary for complete combustion. We analyzed some flue gases recently and the carbon dioxide was only a little above six per cent. The difference between six and ten per cent. in CO_2 means a preventable loss of over ten per cent. of the heat liberated, flue gases being taken at 550° F and air at 90°.

This loss of sensible heat carried away by the waste gases in the average plant is very large. In a test we witnessed recently the temperature of the flue gases just after leaving the last pass of a boiler was fifty degrees F. higher than that of the steam in the boiler. In average good practice this difference in temperature is found to be from one-hundred and fifty to two hundred and fifty degrees F. It is important to make this difference as small as possible as the heat loss from this cause increases with the temperature.

It is also important that the percentage of CO_2 be made as high as possible and at the same time avoid smoke. The theoretical amount of air necessary for complete combustion is very nearly twelve pounds per pound of carbon. If perfect combustion could be obtained with this amount the percentage of carbon dioxide would be twenty and seven-tenths, or the percentage by volume of oxygen in the air. It is not practicable, in most cases, to secure complete combustion with less than thirty-five to forty per cent. excess, due to the inability to secure a perfect mixture of the gases and the short time allowed for combustion. With forty per cent. excess of air we get fourteen and one-half per cent. carbon dioxide. With one hundred per cent. excess air we get ten and thirty-five one-hundredths per cent. carbon dioxide. With two hundred per cent. excess air the percentage drops to slightly below seven per cent. carbon dioxide. When the carbon dioxide percentage drops to between four and five per cent.—a condition not unusual—there is passing through the furnace from four and two-tenths to five and two-tenths as much air as is theoretically required. Just consider the loss due to heating forty or fifty pounds of air five hundred degrees F. for each pound of coal burned! This represents avoidable loss of about five thousand of the fourteen thousand five hundred B. T. U. in the pound of coal. Is thirty-five per cent. of your coal bill worth saving? It is for you to decide how much you can afford to spend, to save it if such conditions exist in your plant. We have been in many plants in which it would pay the owner large dividends to have an expert on combustion do nothing else than look to the carbon dioxide content of the flue gases and work for an increase in its percentage.

Unburned carbon in the ash represents a comparatively small loss, ordinarily. If it is large it will be seen on a close examination of the ash.

Radiation from the setting and boiler surface can be reduced by proper insulation. This loss cannot be entirely eliminated but can be very much reduced.

It is seen from the above that the large losses to be eliminated or reduced are those accompanying the production of smoke or occuring when large volumes of excess air are passing through the furnace. To secure the highest efficiency the air supply should be regulated between rather narrow limits. The best way to do this is to make flue gas analysis a part of the daily routine of the plant Work for a high carbon dioxide percentage and avoid smoke.

As it is the volatile matter in the coal that is responsible for the smoke, its presence in the fuel should be kept in mind when considering the method of operation to be used, as well as when the kind of furnace is to be decided upon.

The types of furnaces which burn anthracite coal to the best advantage are not satisfactory in using bituminous coal. To successfully burn soft coal, that is, efficiently and smokelessly, the furnace needs modifications. Means must be provided to meet the following conditions:

1. The proper amount of air at all times.

2. Provision for mixing air and volatile matter, providing time and space for combustion to take place, making allowance for the expansion of the large volume of gases.

3. Maintaining a high temperature in fire box and combustion chamber.

Under any method of hand firing the rate at which the volatile matter is driven off is exceedingly variable, requiring a proportionately variable amount of air for its combustion. Even if the proper proportions could be maintained it would be of little avail in preventing incomplete combustion and production of smoke, unless suitable provision is made for mixing these gases, providing space for combustion to take place in, and allowing sufficient time. All this would not produce the desired results unless at the same time the temperature of these mixed gases is maintained at a point above the ignition temperature of the chemical compounds of hydrogen and carbon forming the volatile part of the fuel. The ignition temperature of these gases is in the neighborhood of thirteen hundred degrees Fahrenheit.

The conditions in the ordinary hand fired furnace, usually do not conform to the above requirements. Ordinarily the fireman

throws in quite a large charge of coal at one time and he is not so very careful where he places it. Large quantities of the hydrocarbons are driven off in a very short time, the rate at which they are driven off, being greatest very shortly after the coal is placed in the furnace, and becoming less and less as the coal is coked. No hand operated or automatic device has successfully met the demand for so variable quantity of air, therefore the first mentioned condition is not had.

The ordinary boiler is set too low. If it is a return tubular boiler there may be found a comparatively large combustion chamber back of the bridge wall. If piers, wing-walls or other fire brick constructions are found in the combustion chamber, the gases must take a circuitous path and will become more or less thoroughly mixed. Combustion chambers built in this manner are occasionally found. If in good condition and constructed accordingly to a good design, smokeless operation may be had. Care must be taken, however, that the openings or ports in these piers, wing-walls, etc., are so placed and proportioned that the ash carried over the bridge wall will not obstruct the passages for the products of combustion. Several cases have been found where this trouble had been experienced. In addition the cleaning out of the combustion chamber was a very difficult operation, on account of the ash and dust fusing into a glassy cinder on account of the high temperature.

If the combustion chamber is small and the path of the gases comparatively straight there will not be allowed time nor space for combustion to take place. If the hand fired furnace is under a water tube boiler, vertically baffled, and no coking arch or dutch oven used, the path of the gases is very short and little time is allowed for combustion.

If the furnace is lacking adequate space, smoke results from the too quick cooling of the gases. The gases, if they come in contact with the surface of the boiler before combustion is complete, will be cooled much below the ignition temperature. It makes no difference as to how the temperature is lowered or kept low, the result is the same.

You are all familiar with the three systems of firing intended for prevention of smoke, in general use. The coking method of firing, or the placing of the coal at the front of the furnace, either on a dead plate or on the grate, requires for smokeless combustion a large combustion chamber and an arch over that part of the grate

where the coal is being coked. It cannot be successfully used when the fuel is of such a nature that it will not coke well, as for instance the "block coal," mined in some sections. This coal on being heated, crumbles. Other coal forms bad clinkers which give trouble, especially as the coked part, carrying the ash is pushed toward the rear, leaving nearly all the ash and all the clinkers on the back part of the grate where it is with difficulty removed, unless a dumping grate is used.

The alternate method, in which one-half the furnace is fired at a time, the other half having a bed of incandescent coke, is applicable when provision is made to mix the two currents of gases after leaving the fire. For successful operation, a large combustion chamber arranged with fire brick baffles or piers must be used to thoroughly mix the gases.

The spreading method is not satisfactory from either a smoke abatement standpoint or from the standpoint of economy. It requires that very little coal be thrown into the furnace at a time and that it must be spread very carefully. If a large quantity is placed on the hot bed of coke the fire is cooled too much and at the same time such large quantities of volatile matter are driven off that prevention of smoke cannot be obtained. This method is less desirable than either the coking method or the alternate method. The air admitted when doors are opened is destructive to both boilers and setting, besides cooling the furnace below the ignition temperature of the gases.

The use of steam jets is not to be recommended. They are not economical, unless very carefully used. In most cases, they produce lower efficiency than is obtained without their use. By their inefficiency they have done more damage to the smoke abatement movement than they ever did good in abating the smoke. The introduction of steam into the furnace is a poor policy as it cools the furnace. It is the direct cause of water gas and excessive quantities of carbon monoxide, free hydrogen, and hydro-carbons in the waste gases, all of which lower the efficiency. The claim is made that the hydrogen is burned again—and the heat returned to the furnace. Even if it is all burned, which we do not admit, the heat required to raise the temperature of the steam from that in the boilers to that of the flue gases is lost. The only advantages obtained by the use of the steam jet are the thorough mixing of the gases in the furnace, and the introduction of air over the fire, sometimes.

Automatic Stokes

Automatic stokers are advantageous in so far as they operate under the above mentioned conditions for high efficiency and smokelessness and in addition they have the advantage that in general, a cheaper grade of fuel can be used and the labor expense can be reduced.

For small plants the cost of installation per boiler horsepower is greater than for medium sized and large plants. In small plants the reduction in labor is small and it happens in very small sized installation that there is no reduction in the labor. They cannot be installed in very small plants economically. There are certain conditions of fuel and required service which will recommend one machine over another. In selecting the type and particular example of that type for installation, it is a good thing to first study the conditions to be met and the cnditions of good service to see if the contemplated installation is the best for the conditions.

Automatic or mechanical stokers are of two general classes, viz.: —Underfeed and overfeed. The overfeed has two distinct types, viz.:—chain grates in which the grate has a motion of translation and carries the fuel through the furnace and dumps the ash, and the inclined grates, the individual grates of which have a small motion which agitates the fuel, and the fuel under the influence of this agitation and gravity is moved from where it enters to the point where the ash is to be discharged.

In the underfeed type the green coal is pushed under the bed of the fire, and the grate is not exposed to the hottest part of the fire. Very hot fires can be obtained with this type of stoker which makes thetm very adaptable to metallurgical work.

There is in Pittsburgh a plant engaged in making forgings up to three or four hundred pounds, finished.

Ten or twelve years ago the superintendent thought a mechanical stoker could be used advantageously for his heating furnaces. He installed an underfeed stoker and found, first, he doubled the output from the furnace the first day and has gotten a better result at times; second, and most important, from the smoke inspector's point of view, there is no smoke. Needless to say it was only a short time till he had all his furnaces equipped with automatic stokers.

When the underfeed is used for boiler service, a very uniform boiler pressure is had, and if the installation is a good one, heavy overloads may be carried. As this type must depend on forced draft, there is a good chance for securing the proper proportions

of air and coal. The manufacturers of this type of stokers claim that when the apparatus is once adjusted the proportions are maintained, no matter at what rating the boiler is operating.

There are three serious points which are raised against the underfeed stoker. The fan engine must be installed in duplicate to guard against a shut-down. The power for operation is large and in some of the makes the cleaning of the fires is a very hot and disagreeable task, and the saving in labor is none.

The chain grate is always installed with an arch or roof over part of the grate, and usually it is set with a dutch oven. The grate is exposed to the hot part of the fire only a portion of the time. In the best forms the chain is made up of a large number of links which form the grate surface. In passing over the sprockets these links rub against one another, cleaning the grate of any clinkers which may have formed.

The fuel is carried from the coolest part of the furnace through the hottest part, all the volatile matter being driven off while the fuel is yet under the coking arch. As a smoke preventer, this grate is excellent if set properly and operated by intelligent men. With proper operation, very good results are obtained with the best makes of this type of stoker. It has the disadvantage of not being quick to respond to sudden changes of load, as for instance, the starting or stopping of the engine for large rolling mill work, the engine using from ten to twenty-five per cent. of the steam being made. The problem of avoiding excess air is difficult with this stoker; the excess air is liable to come in at the rear of the grate on light loads and also at the sides on any load.

It is difficult to get a fireman to properly regulate his draft according to the load, which is fatal to efficiency, and on heavy loads, fatal to smoke prevention. Of the inclined grate (i. e., gravity feed or avalanche) stokers there are two distinct types. In one, the fuel is fed in at the front, and by agitation it slides down over the bars which present the appearance of a flight of steps. This type offers the serious objection that the fuel hangs and when it is forced to to move it moves too rapidly and slides into the hottest part of the furnace, producing smoke, and usually lots of it. This lack of uniform movement causes air holes in the fire—enemies to high efficiency. It is usually set with little or no coking arch, a necessary part of a smokeless furnace. If the arch is made long enough to be of any value it will soon burn out. We have it on good authority that the Smoke Inspection Department of Chicago

will not approve of some settings having this kind of stoker. Firemen will use the poker or slicing bar from the side doors unless these are bricked up. We have seen the small holes for using the poker in the front bricked up.

There is another form of gravity feed stoker in which the coal hoppers are at the sides of the furnace. A coking arch covers the whole grate and in some cases reaches back beyond the grates. This furnace is not so bad an offender as the form just mentioned. This is due mostly to the presence of the coking arch or roof over the grates. Due to the irregular movement of the coal down the grates, holes are found in the fire, and poking is resorted to . This form has a clinker grinder in the point of the V made by the grates. With a badly clinkering coal a large clinker will form over this clinker grinder and stops the discharge of ash and clinkers. These large clinkers must be removed through the front door of the furnace, before the furnace will operate properly. This is a particularly disagreeable operation.

We recommend the use of mechanical stokers wherever they can be used. The resulting economy, if they are set properly and well operated, will pay large dividends on the investment, especially in plants of three hundred horse-power up. We also recommend the flue gas analysis, if it is continuously and conscientiously carried on, and an effort is continually made to better the plant by correcting all things which it indicates as faulty.

It will do no good, no matter how good an installation you have, if intelligence is not also available in the boiler room. To have an economically operating plant, a much better class of labor must be had than is usually found in the boiler room. If we can convince the men who are responsible for the policies of the companies that the expenditure of a certain sum of money will produce, in their plants, the results obtained in other plants where efficient and smokeless operation are had, the smoke problem will be solved in most cases. There will be a few whom we will have to use a strict ordinance against, just the same as we must have laws to protect society from the naturally perverse.

We have tried to show some of the principal features of the smoke problem and that it can be solved, producing clean cities as well as larger profits to the owners of the various plants. We often hear the expression, "Smoke means prosperity." We think it should be changed to, "Smoke means ignorance, carelessness and waste."

THE INTERNATIONAL SMOKE ABATEMENT EXHIBITION*

PAPER No. 1116

HELD IN LONDON, MARCH AND APRIL 1912

BY GEORGE H. PERKINS, LOWELL, MASS.

(Read October 5, 1912)

Mr. George H. Perkins, Head of the Engineering Department of the Lowell Textile School; represented the City of Lowell, The American Society of Mechanical Engineers and the Department of Commerce at the Conference in London.

An International Smoke Abatement Exhibition and Conference, under the auspices of the London Coal Smoke Abatement Society, was held at the Royal Agricultural Hall, Islington, London, March 23 to April 4, 1912.

The object of the exhibition was to make a comprehensive display of the most approved modern methods and devices for the abatement of coal smoke, applicable either to industrial plants or domestic fires. There were also exhibits showing the injurious effects of smoke deposits upon health, building materials, works of art and vegetable life, with the view of creating an active and intelligent public sentiment on the importance of this widespread nuisance.

The educational work was supplemented by a series of conferences which were well attended by official delegates from most of the principal cities of England and Scotland as well as from Germany, Holland, Sweden, and other foreign countries.

Thet exhibition attracted much favorable attention from the press and general public, and upon the whole was considered a success. The great coal strike which was at its height at the time, while interfering with the attendance and delivery of exhibits to some extent, tended to increase public interest in the affair and to divert attention to the larger question of the conservation of the coal supply.

* Courtesy of the American Society of Mechanical Engineers.

PRESENT STATUS OF THE SMOKE PROBLEM IN ENGLAND

Smoke has been a recognized nuisance in England for nearly a century. As early as the year 1819, Parliament appointed a committee to investigate this question which reported that effective smoke abatement devices existed and should be used. The public health acts of 1875 and 1891 included sections covering smoke abatement which are the only present laws on the subject. These statutes have not proved satisfactory as they are not sufficiently definite and do not make provision for their proper enforcement.

Practically all the effective work done in abating the smoke nuisance has been accomplished during the past 15 years. The great improvement in atmospheric conditions, as far as London is concerned, has been due principally to the following agencies:

a The electrification of all the underground railways formerly operated by coal burning locomotives.

b The rapid increase in the use of gas appliances for heating and cooking. When authorities agree that more than one-half of London's smoke comes from domestic fires burning soft coal, the following figures are significant:

Year.	Number of Gas Appliances in Use.
1891	46,000
1896	223,000
1901	445,000
1906	989,000
1911	1,494,000

c The work of the London Coal Smoke Abatement Society, a voluntary association which has for its objects the following:

1 To aid in enforcing the existing law through the local sanitary authorities, by the employment of inspectors who, after investigation, shall report offenders to the proper officials.

2 To promote and encourage all voluntary efforts to abolish smoke from private dwellings and to investigate the best means for effecting this object.

3 To obtain particulars and evidence of methods of dealing with smoke nuisances at home and abroad.

4 To publish information on matters relating to smoke nuisances, stimulate invention through the offer of prizes

and to conduct tests on heating, cooking and stoking apparatus.

5 To effect the amendment of the present laws with the object of making them more efficient.

Other societies of the same character have been organized in some of the larger cities and are doing effective work along similar lines to that of the London society. One of the most active of these is the Smoke Abatement League of Great Britain which has its headquarters in Manchester and branches in many of the other large industrial centers.

The most direct evidence of the improvement made in smoke abatement in recent years is in the record of observations of atmospheric conditions taken in many of the large cities. The "black fogs" once so prevalent in London and which have been proven to have been due largely to smoke are to-day practically unknown. The winter sunshine of London is to-day about 40 per cent. of that observed in the country districts, which is a figure double that of 30 years ago.

In nearly all of the larger cities a marked improvement along similar lines has been made each year and through the agencies already mentioned. In the manufacturing districts particularly, the boiler users are taking increasing interest in this matter, realizing that it has an important influence upon the efficiency of their plants. The public is also aroused to the situation and the urgency and practicability of smoke abatement seem to be generally appreciated.

Summary of Papers Presented at the Conference

The papers presented at the conference may be grouped under thet following heads:

A Smoke pollution
- 1 Economic and Artistic Aspects.
- 2 Effects on Plant Life

B Smoke Abatement.
- 1 Organization of Preventive Action
- 2 Physical Principles of Smoke Abatement

C Laws and Legislation.
- 1 Proposed New Legislation.
- 2 Administration of Existing Law

(*A*-1) *Economic and Artistic Aspects.*

Under this head papers were read treating of the effects of smoke upon building materials, mural and house painting, ornamental and structural metal work and also the measurement of soot deposits.

Examples were cited of the disintegration of the stone in various buildings due to sulphuric acid in the atmosphere. This acid is formed from the union of the oxidized sulphur compounds, resulting from the combustion of coal, with the moisture of the atmosphere. An analysis of stone taken from St. Paul's Cathedral showed 74 per cent. of calcium sulphate, the original stone being calcium carbonate or limestone. Similar results were obtained on samples taken from Westminster and other well known and historic structures. Limestone appears to suffer more than any other variety of stone while granite is not seriously affected.

The ecect of smoke on mural and fretsco paintings was due to a similar action, the plaster beneath the pigments losing much of its binding power by the chemical change taking place. The effect upon house paint is also very pronounced, particularly on the lead paints. Practically all outside work must be repainted at least once a year. Zinc oxide paints were shown to be more stable than lead pigments against the action of atmospheric acids.

The most serious effect upon metal work is the corrosion of structural steel. Several collapses of iron roof trusses, notably that of the Charing Cross Station, have resulted from this cause. In some instances it was found that about 10 per cent. of the iron had been dissolved into ferrous sulphate. The corrosion of uncovered iron or steel wire has also been observed and found to be extensive.

During the past year the soot fall of London has been carefully measured by means of specially devised soot gages. This work has been in charge of the officers of the Smoke Abatement Society and the extraordinary results obtained may be summarized as follows:

The total yearly deposit from the atmosphere was 650 tons per square mile, or a total of 76,050 tons per annum for the entire administrative county of London of 117 square miles. This figure includes 8000 tons of sulphates, 6000 tons of ammonia and 3000 tons of chlorides, the balance being carbon and tarry products. The deposit per square mile at Surrey, on the border of the metropolitan

area, was only 195 tons per year, or less than one third that of London proper, showing clearly the comparative purity of country air.

(*A*-2) *Effects on Plant Life*

Evidence was given by the authorities in charge of the Kew Gardens and other parks as to the difficulty of maintaining vegetation in smoke affected districts. Only a few hardy plants and shrubs will survive the winter season in the large cities. The main effects of smoke on vegetation are due to the following:

1 Reduction of light and heat from the sun.
2 Soot deposits excluding still more light.
3 Tarry deposits blocking the pores of the plants.
4 Acid deposits lowering the vitality of plants.

The effect upon health of smoke polluted atmasphere was clearly shown by figures given from Glasgow, where a study has been made of the effect of smoke fogs upon the death rate from bronchial diseases such as bronchitis, pneumonia and pleurisy. The deaths from these diseases alone increased at a remarkably rapid rate during prevalent fogs and could be traced to no other source.

(*B*-1) *Organization of Smoke Abatement Work*

The work of the various smoke abatement societies was described in detail and many suggestions were made regarding the possible future study of this problem. The majority of these suggestions were along the line of determining the actual economic loss to the community caused by smoke, it being generally conceded that the engineering side of the question is well in hand and sufficiently well developed to meet practically all conditions provided careful study is made of the factors involved.

Some of the elements in the economic loss to a city are as follows:

1 Added cost of artificial illumination.
2 Added cost of painting exteriors and interiors.
3 Added cost of laundering and other cleansing.
4 Damage to goods in stores and factories.
5 Effect of gloom upon the efficiency of workers.

Recognition was made of the splendid work done on smoke abatement in Cleveland, Ohio, and Chicago, Ill., where the progress made within the past five years has been remarkable. In both of these cities the problem is handled by efficient depart-

ments of the municipal governments furnishing a most excellent example of honest, effective and thorough public service. These two cities are without question well in advance of any other American municipalities in the matter of smoke abatement.

(*B-2*) *The Physical Principles of Smoke Abatement*

The papers presented under this head covered various phases of the subject, including the effect of smoke upon steel making, losses due to incomplete combustion, hand and mechanical firing, the manufacture of smokeless fuels and the construction and operation of producer gas plants. The production of steel without objectionable smoke was held to be practicable, without affecting the quality of the steel.

Results of tests weret given showing the loss due to unburned combustible matter in smoke and that due to a non-conducting layer of soot upon the surfaces of boiler tubes and plates.

The value of trained firemen was especially emphasized and the subject of hand firing and conditions under which it might be successful were discussed. It was proposed to add to the present license for firemen, a certificate of competency based upon a knowledge of proper conditions for perfect combustion, heating value of fuels, etc.

(*C*) *Laws and Legislation*

The larger part of the matter presented under this head would not be applicable in this country for obvious reasons. A strong plea was made, however, for uniform and definite legislation on smoke abatement. The principal paper in this group urged the appointment of a royal commission to inquire generally into the subject of smoke emission for the purpose, if possible, of having a stringent general law passed by Parliament. It was suggested that this royal commission, if appointed, be directed to inquire:

1 What standard, if any, is desirable as to the color or density of the smoke which should be deemed a nuisance?
2 How the color or density of smoke can best be identified?
3 Are the fines at present inflicted upon offenders sufficiently adequate to act as deterrents?
4 Who should be punished, the owner of the works, the engineer in charge, or the stoker, when smoke nuisances result from the careless manipulation of well equipped installations?
5 Should any industries receive special treatment?

6 Should Government inspectors be appointed to act in regard to the emission?

7 Should Government premises be placed under the obligation to prevent smoke nuisances?

8 Ought any hourly or other time limit be fixed during which black or other smoke may be permitted to issue from factory chimneys?

9 Should all cases be heard by stipendiaries? (Paid Magistrates.)

10 Can the issue of an unreasonable quantity of smoke be prevented except in cases of accident or breakdown?

11 Can it be shown that the installation of proper appliances generally results in economy as is contended by "smoke abaters"?

12 The incidence, intensity and duration of fogs and their effects on health.

13 The influence of smoke on health.

14 The damage of smoke to buildings, works of art and property generally.

15 Foreign efforts to cope with the smoke nuisance.

16 How far is it possible by smoke abatement to conserve the coal supply?

17 How far is it practicable to deal with the smoke from private dwelling houses?

Classification of Exhibits

The exhibits may be classified into the following groups:

a Boiler furnaces; special grate bars and furnace construction; mechanical stokers of all types; smoke preventing devices of various kinds; fuel economizers; briquette making machines.

b Suction gas plants; gas and oil engines.

c Open coal-fere grates; stoves and ranges of all kinds; draft regulators and other smoke preventing appliances for domestic fires.

d Gas stoves and grates; gas heating and cooking appliances.

e Electric heating and cooking appliances.

f Testing devices, including anemometers, tintometers, soot gages, automatic gas analyzing devices, etc.

g Fans and other appliances for the removal of dust of various kinds from industrial plants.

h Smokeless fuels, both natural and artificial.

While there was little essentially new in the principles underlying the various devices exhibited, there has been a marked improvement made within a few years in their design and mechanical construction. There was also evidence of an appreciation and careful study of the theoretical side of the question which has undoubtedly contributed largely to the relatively better results obtained in recent years. The exhibits were so numerous and varied that only the most important will be mentioned.

Mechanical Stokers

The stoker which appeared to bet considered the best adapted for the prevailing conditions in England is the chain grate type.

When used with the proper fuel, preferably bituminous slack, this type appears to meet the requirements of smokeless combustion more nearly than any other device, particularly with water tube boilers. The best sample of this stoker exhibited was by the Babcock and Wilcox Company.

A number of types of coking stoker were shown, the best being those made by J. Hodgkinson of Salford and E. Bennis of Bolton. These stokers are better adapted to the Lancashire type of boiler, since they are not readily forced. In their action a reciprocating ram, mechanically driven, and located in the bottom of the hopper, forces a small quantity of fuel on to a "dead" or coking plate at each forward stroke. While the fuel remains upon this plate the volatile products are driven off and the coked coal then drops upon the grate bars which are of a sliding type and actuated by a cam motion on the front end. The mass of the fire is constantly carried toward the rear of the furnace by an intermittent and simultaneous movement of all the bars, the return stroke of each bar being independent.

There were a number of forms of sprinkler stoker shown which, although of ingenious design, have not proved satisfactory where smokeless operation is desired.

While there were no underfeed stokers exhibited, there are a number of English machines of this class giving satisfaction under the proper conditions. The best known are the Vickers,

Bennis, Underfeed and the Proctor. This type of stoker is not so well adapted for use with the average fuel available in England and is not so extensively used as in America.

Patent Furnaces

There were many exhibits under this head, only a few of which possessed real merit. The majority of these appliances consisted simply of properly controlled steam jets with special forms of grate bars. There were a few good devices for the automatic regulation and timing of the supplementary air supply, both over the fire and below the grate. The best of these was the Kowitzke furnace which was excellently designed and simple in operation.

Various types of furnace construction, designed to effect a better mixing of the gases, were also shown. The Gregory patent furnace makes use of a supplementary jet of vaporized fuel oil ejected over the fire, which is claimed to add materially to the efficiency.

A special boiler known as the Bettington is dsigned to allow the use of a mixture of air and pulverized fuel or coal dust, introduced by air blast at the bottom of the boiler which is of the vertical type. This boiler is intended for use at mines or wherever fuel of a finely divided character is available.

Miscellaneous Devices

A device for the optical analysis of the gases of combustion by means of a interforometer was shown by Carl Zeiss and Company. It is based upon the principle that the refractive power of the gases is dependent upon the content of carbon dioxide. A gas refractometer is so calibrated that the analysis of the gas may be read on the scale bysimple inspection. A special form of tintometer was also shown in a portable form for gaging the density of smoke or fog.

The numerous forms of appliances adapted for domstic uses, all showed improved features, but need not be described here.

Other interesting exhibits included "Coalite" and other artificial smokeless fuels, spark and soot catching chimney cowls and special chimney construction for effecting a dilution of the smoke as it is emitted.

Cgnclusions on Smoce Abatement

In judging of the merits of the various types of mechanical firing appliances exhibited, it should be recognized that all of these devices were designed for local conditions and for burning English or Scotch coals. These fuels cost from $2.50 to $3.50 per ton at the plant, contain from 30 per cent. to 35 per cent. volatile matter and 11,000 to 13,000 b.t.u. per lb. In these respects they correspond to our Illinois or other western coals. This class of fuel is not available in New England for economic reasons. The freight charges on coal in this section amount to about $3.00 or nearly three quarters of the average cost of fuel per ton. It is therefore not feasible or economical to burn any but the highest grade of bituminous coal in this part of the country for industrial purposes. This class of fuel should contain about 14,000 b.t.u. per lb. and not over 20 per cent. volatile matter. On the chain grate, for example, which gives excellent results in England, this coal could not be burned satisfactorily. It would be impossible to maintain a proper ignition temperature with such a low per cent. of volatile matter without an excessive draft which would give large losses to the stack. The chain grate is meeting with success in this country wherever fuel of the lower grades is available.

Of the other devices, perhaps the most important are those automaticaly controlling the air supply, both over and under the fire. These eliminate the personal factor of the fireman and should be effective on any type of hand-fired furnace.

In conclusion, smoke abatement may be best effected in the present state of the art of fuel burning by thorough consideration of the following conditions. Careful attention to one or all of these factors by competent engineers will increase the efficiency of any plant and with efficient combustion comes smokeless operation.

1 Selection of a suitable fuel with provision for maintaining same at fixed standard of heat value.
2 Careful scientific study of the conditions prevailing in the plant, including draft, composition of gases, temperatures, etc.
3 Design or selection of type of furnace or apparatus best adapted to meet these conditions.
4 Proper construction or installation of same.

5 Careful selection of operating force.
6 Suitable instrumental aids or guides for the fireman and responsible engineer.
7 Frequent and thorough inspection to insure maintenance of highest possible efficiency.

Work of the Hamburg Smoce Abatement Society

Among the delegates present at the London conference was Herr Nies, chief engineer of the Vereins fur Feuerungsbetrieb und Rauchbekampfung, of Hamburg, who later extended to the writer, in Hamburg, many courtesies which brought him into contact with the work of the society.

The Hamburg society, which was organized in 1902, is essentially defferent from other organizations of this character in the following important features:

a It is an entirely voluntary organization of manufacturers and other boiler users bound together only by a common desire to obtain greater efficiency and less smoke from their power plants.
b The working staff of the society is composed wholly of technically trained engineers.
c All boilers owned by members are under the systematic and scientific control of the expert staff of the society.
d All members benefit mutually by the published results of all tests and investigations made by the engineers.
e The economy of smokeless combustion is the cardinal principle and the members have been convinced of this in a most practical manner, in the savings effected in a fuel consumption by their co-operative effort.

The society now numbers 436 members, representing 1381 boilers. The annual dues of members are small, being only $5 and $5 additional for each boiler in their plants. The society is entirely self-supporting and draws its funds from three sources, annual dues, payment for special work or reports, and payments for outside work.

The education and control of firemen in the proper performance of their duties are also undertaken by the fireman instructors on the staff of the society.

Comparative tests of fuels, smake preventive devices, etc., are carried out by the engineers and the results are circulated among

the members. Advice is also given on purchase of fuel, the buyers being educated by the engineering staff to appreciate the importance of this matter.

The egineering staff of the society consists of a chief engineer, four assistant engineers and eight trained firemen who act as fireman-instructors. For the chemical and thermal analysis of fuels, the society avails itself of the testing laboratory of Dr. Aufhauser, at Hamburg. This laboratory, which is one of the most complete of its kind in Germany, tests about 2000 samples of fuel annually. Dr. Aufhauser also edits a periodical called "Smoke and Dust," to which the engineers of the society are frequent contributors.

The work of the Hamburg society is as practical and effective scientific work as is done anywhere along these lines. The efficiency of the plants, under its control, is materially bettered and maintained, the owners derive a substantial economic gain and the smoke problem is solved without the aid of the usual unsatisfactory legislation.

DISCUSSION

CHAIRMAN.—I will call upon Dr. Herman B. Allyn, representing the Philadelphia County Medical Society, who will talk upon the subject from a sanitary point of view.

DR. HERMAN B. ALLYN.—One of the most gratifying things is to learn that one of the most important cities of the State has taken up an investigation which will be a benefit to the entire country. It does seem that an investigation of this sort should be so thorough that nothing will be left out, nothing left undone, and I very much hope that the commission having this matter in charge will be able to report on it at no very distant date.

Regarding the collection of dust and soot, one might consider it from several points of view. In the first place, the effect of smoke and soot upon buildings and upon draperies and hangings, and the effect of obscuring the sunlight; or one might consider it from a purely economic standpoint, the effect of smoke and soot in its depreciation of property, by the chemical action of soot and also the enormous waste, something like 30 or 40% if I recollect.

But the effect of smoke and soot upon the health is a matter which naturally interests me most, and in this respect, of course, we are not able to do what Mr. McBride's experiment with vegetables has done, because until after a person's death we are not able to tell how much smoke and soot he has absorbed, so it is not easy to state in regard to any individual or individuals just how much damage has been sustained. We have known, however, that in mining communities, the miners have absorbed sufficient coal to transform their lungs into a material about as black as the hats they wear, but the damage sustained is difficult to estimate.

The problem may be well likened to that which we had with respect to typhoid fever in Philadelphia before the advent of filtered water. We felt that the outbreak of typhoid was due to the contamination of the water, but you will remember that it was very rarely possible to find the typhoid bacilli in the water. We do know, however, that after filtered water came, the typhoid almost disappeared. I do not know that I have seen a case of typhoid fever which developed in the district in which I live in West Philadelphia since we have had filtered water. I know, of course, that there have been cases among people who have returned from Atlantic City or other summer resorts, the disease having been contracted while they were away. But cases of city origin in the districts supplied with filtered water have been very few.

We are in somewhat the same position regarding the evil effects of smoke and soot. We believe they are injurious, but we may not be able to prove it conclusively until we compare the city health after smoke and soot are nearly abolished with health conditions as they exist today.

Now in regard to the health of the individual. If we could know, for instance the health of Pittsburgh before and after, as we will be able to do some day, we could show that such and such ill health was due to smoke and soot. In Germany there are certain districts, such as Essen, which are very smoky, and there are others which are not, and the differences in prevalent diseases are striking. Louis Ascher, who investigated health conditions at Essen where the Krupp Works are, and compared them with those at Krefeld, an enterprising town in the same district of Rhenish Prussia, but g ven up to textile manufactures, found quite a considerable difference. What he found was that in this textile district of Krefeld, where they make tapestries and silks, there was a larger morbidity from tuberculosis, whereas in the Essen district they had a larger morbidity from very acute lung infections, namely, pneumonia, bronchitis and the like. The difference was, as I remember, about 130 as compared with 40, showing greater liability to acute lung affections in the district where there was the most smoke. I wish we had some definite statistics in regard to our own country.

Ascher did another interesting piece of work. He investigated the effect upon animals who were kept in a smoky atmosphere and then inoculated with a disease. He found that they died in a much shorter time in such smoky atmosphere. He also reports that in regions where there is a great deal of smoke, while there is less tuberculosis as compared with the district where textile industry predominates, but the air is not so smoky, yet the duration of life is shorter for those who have tuberculosis, showing that smoke has a distinct influence upon the duration of the life of the tuberculous patient. That is, he has fewer years to live in a smoky atmosphere than in a clear atmosphere.

In a lecture on Smoke Abatement, delivered at the International Health Exhibition, in 1884, by Ernest Hart, he quotes Sir. Wm. Gull, as follows: "It is clear that smoke and fog, not only touch, but kill the life of man." Sir Andrew Clark, Sir Henry Thompson, Sir T. Spencer Wells, Prof. Corfield, Dr. Ransome (of Manchester) and other eminent medical authorities have added their testimony:

"Sir Andrew Clark writes to me: "I, for my part, have no manner of doubt that a smoke-laden atmosphere exercises an injurious influence upon the health,

moral as well as physical, of those persons who dwell in the midst of it. A smoky atmosphere, both by its exclusion of light and by the irritating particles suspended in it, is hurtful to the lungs and air passages; it aggravates the discomforts of sufferers from heart disease; it deepens the distress of the nervous; it lowers the tone of general health; it adds perils to the sickness of the aged; and it materially diminishes that brightness and buoyancy of spirits which contribute so much to the power and gladness of life.'"

During the five years, 1868–1873, the average death-rate from diseases of the respiratory organs was 2.27 per 1,000 in Westmoreland (one of the healthiest counties in England) and 2.51 in North Wales.

For the whole of England and Wales it was 3.54; for Salford, 5.12; and for the Registration district of Manchester, 6.10. Taking, however, the township of Manchester alone, it appears that in 1874, the last for which returns have been published by the Registrar-General, the death-rate from these diseases amounted to 7.7 or three times the average of healthy districts, and more than double the general average for town and country districts—healthy and unhealthy. If, therefore, the rate could be reduced to the average for all England, there would be an annual saving of more than 700 lives in Manchester alone.

In 1873, the deaths in Westmoreland from diseases of the respiratory organs were 13.7 per cent.; in all England and Wales, 17.2 per cent.; in Birmingham, 18.2; in Liverpool, 18.7; in Sheffield, 21.0; and in Manchester, 21.6 per cent.; but excluding the out townships, the rates in the township of Manchester alone amounted to 23.2 per cent. It appears therefore, that Manchester suffers more from diseases of respiratory organs than any other town or city in England; and it may be safely affirmed that if no means can be found of reducing the number of deaths from this class of diseases, it is hopeless to expect that any material improvement can be made in the general state of the public health, or any sensible reduction effected in the general death-rate of the city. (Extract from Manchester and Salford Sanitary Association Report.)

There is reason to fear that our condition may, in the course of time, be as bad as those in the smoky cities of Manchester and Birmingham I have mentioned. The remedies are education and an aroused public sentiment against smoke.

Dr. Anders.—Speaking in connection with my colleague, Dr. Allyn, as I had the privilege of doing once before on an occasion when this question was brought up, I can only reiterate and emphasize some of the points I tried to urge at that time, and those that have also been touched upon tonight by Dr. Allyn.

There is no question but that the undue prevalence of smoke is not simply a matter of waste and extravagance from an economic standpoint. It is not simply a matter of defacing public buildings, the destruction of fabrics, furniture, clothing, etc., things which appertain to domestic life; it is not, as I understand it, a nuisance to public comfort only, but it is distinctly a menace to public health; and as representatives of the profession and representing the societies we do, it is our duty to bring the matter to your notice tonight. There are those connected with the laboratory who have failed to notice the influence smoke has on the public health; but those who are practising physicians cannot but believe definitely that smoke prevalence counts for a great deal in its influence upon the public health. Of course, as a direct cause of disease it no doubt ranks decidedly

less, say than the dust menace, which we know not only carries irritation to the mucous membranes, but also infection. I think that as a simple test, one may realize that the habitual inhalation of smoke affects one's physical feelings and induces a susceptibility to colds and catarrhal diseases, especially on our Atlantic seaboard where soft coal is much used. For instance, if you have a tenddency to "hawk," the throat blow your nose, especially during foggy weather, in winter when we have some of those "grouch days," when no air is stirring and the humidity is high, the temperature is high and the air is laden with fog—if you are in an atmosphere like that all day and the next morning you blow your nose and clear your throat, you will find you have inhaled a lot of smoke or carbon particles. Apprehensive people will go to a physician when they find they have spat up a lot of black mucus, which the irritation has elicited, and sometimes they will think the conditions are worse than they really are. It is nothing more than the floating about of smoke particles, and I think the time is coming when it will be as important to flush one's nose and throat at night before retiring as it is to cleanse one's teeth before going to bed. Smoke also gets into the larynx and the bronchial tubes. So that we have a problem which not only affects nasal and throat passages, but there is no doubt that certain acute diseases are predisposed to by smoke irritation, as the infectious pneumonia and catarrhal or broncho-pneumonia. Along the lines of tuberculosis, in which I have had some special experience, while smoke does not produce this widespread malady, it is not at all a negligible factor, but also adds to the predisposing causes. The irritation which smoke produces in the bronchial passages also helps to aggravate the tuberculous condition of people who are compelled to live in such an atmosphere. They are compelled to live where they are deprived of sunlight, because of the obscuration of the sun: and they are also subject to membrane irritation by the smoke particles, and are subject to the effects of sulphates and carbon dioxide which are concomitants in this atmosphere. So that these elements are of extreme importance in tackling the question from a public health standpoint: and if a community fails to pay attention to its public health, it is failing to do its duty to the government and the people which support that government.

I would like to speak of one thing that has occurred to me within the last few days, although it might appear to be a digression from the main issue. I suppose some of you have been annoyed at times by automobiles sending out excessive oil smoke into the atmosphere. I would like to advocate an agitation for the passage of some statute or ordinance that would compel, or as nearly as possible compel, automobile exhausts to be directed backward instead of downward and backward, or downward at any angle. Why? Because you will observe that on an asphalted street the impact of gas is very sharp, and is not only deflected upwards with more violence into your face than it would be if the exhaust pipe were turned upwards, but also, on a dry day the impact of that gas and smoke pressure creates an extra cloud of street dust. I think it would be wise to advocate rules that the exhausts should be directed upward and backward rather than downward, so as to avoid that deflection into the faces of pedestrains, and also to avoid the simultaneous starting up of that great cloud of dust, which in itself is not only irritating, but often infectious.

That is another point which seems to me important in connection with pub-

lic health, and which might be taken up as an appendix to the coal smoke problem.

MR. HENRY G. MORRIS:—Mr. President. As pertaining to this subject I would like to call the attention of the older members particularly to a work published by Charles Y. Williams, in 1845, in which he discusses the whole subject of smoke abatement. He was appointed by Parliament to report on the subject of smoke nuisance, and his official conclusion, after giving details of all manner of grates, furnaces, appliances, etc., in use at that time, was this. "The reason that people did not burn the smoke was, that it did not pay," and I guess that is about the size of it today. There are plenty of methods of consuming smoke. The water jet in the base of the stack is quite efficient and easily installed—just a little steam pump. I call to mind a plant up in Lancaster, Pa., where they double their boiler capacity in the same stack, and where they are able to burn bituminous coal without any smoke coming out. I do not know whether it has been installed here or not, but it is a simple operation, and what the economic effect was, I do not know; that is easily found out, however.

Of course, in iron heating furnaces you cannot burn bituminous coal without smoke and get any good results. For instance, if you burn your fuel completely you will burn your iron.

I would call attention to my paper read before this Society, in 1903, on the Gaseous Fuel Question. You will find it in the Journal; in which I pointed out that there is ten times as much coal used for heating the city as there is for lighting. What we want to do is to increase our consumption of gaseous fuel, and do away with our bituminous and other fuel. It costs us more to deliver coal than it is worth; when you think of the destruction of carpets and everything else; and if the United Gas Improvement Company would recognize the fact that they could consume ten times as much fuel as they do and sell their gas for heating, we would have a much better condition in the city of Philadelphia, and we would reduce our cost of gaseous fuel to where it ought to be.

More than twenty years ago the cost of gas in Milwaukee, which then had only 240,000 inhabitants, was 48 cents delivered at the consumers' meter. If you were to make five times as much gas as you are using here, you could reduce it to 80 cents.

PROF. FERNALD.—I am somewhat reluctant to speak on this topic, as I am almost a stranger to Philadelphia. It was my good fortune to live in Cleveland twelve years, and in St. Louis five years. I spent a day or two a week for many months in Pittsburgh and have had considerable to do with smoke problems. In Pittsburgh I have had charge of some of the Government work relating to smoke problems and problems of combustion. My attendance here is purely accidental, but I am much interested in this problem, and there are some points regarding it upon which my views may not coincide with those which have already been presented by some of the gentlemen here.

Many of the points touched upon are exceedingly important, and I think we are working in the right lines to stimulate interest. Before we can do much with smoke prevention, we have to stimulate public interest and mould public sentiment. To my mind it is folly to start out in the political camp to solve

the smoke problem. To make political appointments, and to carry on the work as a political proposition, expecting to clean up the smoke problem in two years, three years, or four years, is not the right way to go about it; the political factor must be eliminated. I believe it necessary to start out with a twenty-five year proposition, nothing less. In Cleveland, Pittsburgh, or in St. Louis, it may take even longer. In Philadelphia we ought to start immediately. I have not been here more than three times in my life, and I thought Philadelphia was a clean city until today when I was much astonished, in looking from a high building, to see the amount of smoke you have here. It seems to me it is necessary for you to get busy before the conditions get thoroughly bad. The smoky condition here is creeping in slowly and ought to be checked. It is entirely possible to burn soft coal without making smoke, but it takes an exceedingly careful study of the type of furnace and other conditions relating to draft, etc. A couple of examples will illustrate.

In tests made by the Government in connection with torpedo boat service, attempts were made to use briquettes made from bituminous coal in an effort to eliminate smoke, so the boats could steal into harbors without being detected by a line of smoke behind them. Under the bow boilers the raw coal was used, and in the stern furnaces the briquettes were used. The draft carried with the briquettes was only half that required for the raw coal. The steam gauges on the boilers in which the raw coal was carried did not get up to full pressure, while the boilers used with the briquettes were blowing off during the entire trip with the boat making a speed of 30 knots. There was a slight trail of smoke with the raw coal, and tremendous volumes from the briquettes from which no smoke was expected. The combustion took place all the way up the stack and way beyond the stack. The question was one of improper combustion space for the fuel used.

If you go into the Government Testing Laboratory at Pittsburgh, you will find there a combustion chamber 40 feet long, with a Murphy stoker. They burn there 40, 50, 60 and 65 pounds of coal per square foot of grate area per hour and get no smoke. Perfect combustion is established before the gases reach the end of the combustion chamber. The same thing can be done elsewhere. A given coal can be burned and burned efficiently, with proper settings and proper furnaces.

I am not altogether in sympathy with trying to create too strongly the impression that smokeless combustion is a big money saver. It is a money saver indirectly; for instance, in Cleveland it has been estimated that the annual cost due to incidental troubles from smoke amounts to $12.00 per capita or about seven and a half million dollars per year. But then comes the question of whether a manufacturing plant is working more efficiently when it is making smoke than when it is making no smoke. There are conditions under which you can run your plant without smoke, and these are the ideal conditions, but the average manufacturing plant, as manufacturing is done today, is developing much more rapidly than the boiler equipment and the power plant itself, and the result is that the owner is trying to get two or three times the designed capacity out of the boiler plant in order to get efficient returns from a manufacturing standpoint. There are two problems: One, efficiency from the operation of the coal; and the other, efficiency from the standpoint of the manu-

facturer. The smoke inspector may say "you ought to spend thousands of dollars to rebuild the power plant." As I said before, I think, smoke elimination is a 25-year proposition, and if I were going at the thing, I would outline something like this: Get public sentiment with you, eliminate politics, and appoint a commission of engineers to attack the whole problem from an engineering standpoint. I would not fine everybody that makes smoke now, but would frame laws in such a way that every new plant that goes in and every old plant that is remodeled must be adapted to the local coals which are to be used. In this way the problem will be gradually worked out, although it will take years, because there are a great many boilers that have just gone into new plants and a good many plants that have just been remodeled.

Further than this, there are very few engineers in the country today sufficiently familiar with the problems of combustion to enable them to design with guaranteed success furnaces adapted to the wide variety of fuels. Careful researches and investigations are already under way relating to this subject, and the time will surely come when competent engineers can be secured for handling this particular part of the problem.

MR. LUKENS.—In reference to smoke, I would first call your attention to the Ordinance of Council, passed December 9, 1904.

Two men have been appointed at salaries of $1,200.00 per year. It is their duty to take observations and report violations to the office.

The offenders are informed of such violations and are notified to appear at the office and are instructed to make some provision for eliminating the smoke, and after being given sufficient notice and no provision has been made for the abatement of the smoke, legal action is then taken. The Bureau has found it necessary to take action in 104 cases and this has caused a considerable reduction in the smoke nuisance; but during the last anthracite coal strike, many manufacturers were compelled to lay in a considerable amount of the soft coal. Many of these were anthracite coal users and we have had considerable difficulty to have them return to the use of anthracite coal.

There have been installed in the city: 143 Murphy stokers; 96 Rooney stokers; 11 Jones underfed; 36 Taylor underfeed; 4 chain grates; 83 steam jets and automatic shaving feeds.

There has also been an abatement of smoke by 110 plants returning to the use of anthracite coal, thereby eliminating many complaints of the smoke. The complaints have not been confined to the stationary plants as the Bureau receives many complaints against the smoke from the railroads; and under the ordinance of Councils, ten (10) minutes are allowed for emitting smoke from locomotives when preparing fires, but does not specify in what time this 10 minutes smoke is allowed, which practically means a continuous smoke in the West Philadelphia Yards, where the fires of 300 locomotives are prepared daily, causing a considerable amount of smoke to be emitted. A large number of offenders are located along the railroads, and when they are compelled to make provision for abatement and comply with the law, they complain that they should be granted the same privilege as the railroads.

I believe if we could get the newspapers interested and public sentiment aroused, the smoke nuisance could be reduced to a minimum; and it is useless

to pass an ordinance making it a misdemeanor for one line of business to emit smoke and at the same time exempt some other form of business which may or may not be a greater nuisance.

MR. HARTLEY.—This subject is not familiar to me just at present; in fact, I did not know what the subject announced for this evening was going to be until I arrived here, consequently I have given it no thought. However, it is a very important one in connection with the prevalent reform spirit now extending along sanitary lines of hygienic improvements. It is also of such scope as to exclude the possibility of thoroughly discussing in one evening the many means for eliminating the smoke nuisance.

Speaking from memory, I think we had this subject under discussion before, and about the time Mr. John M. Hartman was championing a bill before our City Councils—the object of which was for an Ordinance looking to compulsory means for abating, at least to some extent, the smoke nuisance. But unfortunately by the time the bill had got through that body it had been so mutilated as hardly to be recognizable, and what was left of it seemed to favor locomotives and all low stacks, as the Ordinance permitted the issuing of black smoke from stacks of a height covering that of locomotives; while for higher chimneys the color was restricted to a light gray.

To come to the principal cause of the existing smoke nuisance in this City, apart from the scientific principles therein, lies simply in the well known facts of the lack of boiler capacity in many of our manufacturing plants, owing to which necessitates heavy firing or the forcing through the furnaces of probably double the quantity of fuel that can possibly be perfectly consumed, in order to make up, as supposed, the power deficiency. In other words, should perfect combustion of say 15 pounds of soft coal be obtained per square foot of grate surface under natural draft, and giving off a minimum amount of smoke, the same result could not be expected if the amount of coal be increased, other conditions being the same, consequently a voluminous amount of smoke.

However, I notice a marked improvement in regard to smoke conditions over former years, due probably to more stringent measures and better knowledge in regard to firing of boilers and the general use of butiminous coal.

PAPER NO. 1117

THE DEVELOPMENT OF UNIT STRUCTURAL CONCRETE

Paper read before the Club

BY CHARLES D. WATSON

(Active Member)

Read October 19, 1912

While the Engineering Profession is somewhat familiar with the development in the construction of reinforced concrete buildings by what is known as the "Unit" method of erecting a building of previously moulded members, their acquaintance with the subject has been more or less through isolated and experimental developments, and few of them realize the scope of application and large amount of work in which these methods are now being employed.

It is not the object of this paper to enter into a long technical discussion of the merits of design of the unit method, which some of us believe to be based upon more rational and economical principles than commonly practiced, but rather to call attention to the extent of the development which we believe will some time culminate into standard practice for typical reinforced concrete building construction.

I think it is conceded by most engineers that our present common practices in reinforced concrete construction are crude and unscientific;—unscientific for the reason that we are compelled to use relatively large factors of safety owing to the unreliability of the quality of concrete which is made in the field and deposited in forms under the so-called "monolithic" system, and uneconomical on account of the enormous waste in materials for making forms.

The science of concrete construction is to a certain extent passing

through the same development through which iron and steel passed not so many years ago. Much credit for the present high development of this science is due to the manufacturers, who by perfecting processes, have given us a product which runs so uniform that factors of safety of three are common practice.

Under properly controlled conditions, it has been demonstrated that concrete can be made with an ultimate compressive strength averaging from five to six thousand pounds per square inch at sixty days of age, yet under our present practice in design it is quite uniformly conceded that six to seven hundred pounds is as high a limit as we are safe to take as the working stress. While this seems like an absurd factor of safety as compared with other structural materials, the development of the science has been fraught with too many accidents to warrant our taking higher working stresses.

I think it safe to say that the majority of failures in concrete construction are directly traceable to inferior concrete, and the greatest problem of the engineer is how to insure getting a material of proper quality, and strict adherence to design under present field methods of construction since unlike all other structural materials the members are moulded in place and cannot be previously tested or inspected until they become an integral part of the building, after which correction of defects is practically impossible.

With the constantly increasing price of lumber, the unsatisfactory results obtained by standard steel forms for monolithic construction, and the testimony of many of our largest contractors to the effect that the cost of temporary forms for structural concrete now averages from one-third to one-half of the total cost of the structure, it is evident that there is an opportunity for large economy in form expense.

These are the two primary incentives which have led to the development of the unit system of concrete construction under which the members are separately moulded either in a permanent or temporary factory, where practices can be standardized and conditions created to insure a uniformly high grade concrete, and the form expense reduced on account of its being possible to remove the forms much quicker than they can be in a monolithic structure, with the consequent reduction in the number of forms required and thus the cost.

An offset against the saving in forms is the special equipment required to economically handle and erect the units after manufacture. Great credit is due those who have been most instrumental in the development of this system for the bold manner in which they have attacked this problem. Realizing that the application of modern labor saving devices to building has been far behind its application in the other industries, they have conclusively shown that the old hand methods on which little improvement has been made for centuries, are capable of being made much more economical by the application of modern machinery for handling large heavy members.

The problem that at once comes to an engineer's mind when the unit method of construction is mentioned is whether or not a building so constructed will be as rigid and stiff as the so called "monolithic" construction. The first question asked is how can concrete units be connected to insure proper stability in the completed structure? Such a question is obviously well taken as concrete is not a material like steel and timber, which makes it impossible to apply the common practice of structural steel and mill construction connections.

It is probably in the solution of this problem that the greatest progress has been made in recent years, yet the solution has been comparatively simple—the principle of design of unit connections being identical to the design of the structure itself, namely, the bond between concrete and steel, sufficient steel being exposed at the connection so that when the joints are filled with concrete it insures complete development of the steel and concrete for the tension and shear stresses.

Many make the mistake of assuming that the so-called "monolithic" concrete structure is really monolithic. We who are familiar with the actual practice in pouring concrete in such a building know how impossible it is to deposit concrete continuously so that all parts of the building, or even one floor, will have the successive batches of concrete deposited before the preceding batch takes its initial set. The result is always a building of comparatively large monolithic units, the joints coming at such places as field conditions allow. By unit methods such joints always come at predetermined points.

It is a fallacy in criticizing the design of a structure built up of

previously moulded units as compared with a building built by the so-called "monolithic" system, to assume that the concrete, being more or less continuously deposited, gives a more rigid and safer structure. Such an assumption can only be based on the hypothesis that it is the strength of concrete in tension which ties a building together instead of the steel. We all know that the basis of theory of design for concrete and steel is the bond between concrete and steel, therefore, to construct a building of previously moulded units it is only necessary to work out the details of connection to insure a proper bond of the steel, to obtain equally strong and rigid structures as can be built by the so called "monolithic" system. As a matter of fact, the continuous casting of large volumes of concrete where heavy and light sections such as girders, columns, and slabs are made monolithic, has lead to some of our greatest diffiiculties in concrete construction, the worst of which has been the proper provision for reinforcement to prevent cracks by differential temperature expansion, and shrinkage of concrete during set.

By the separately moulded method the shrinkage takes place before the member is in position, and the best of opportunity for properly taking care of temperature stresses and expansion is afforded by the large number of joints between the field and previously moulded concrete, among which the total movement is so distributed as to make the movement at any single point imperceptible.

In addition to the advantages as regards theory of design above mentioned, the separately moulded system has proven advantageous in that the members can be finished within a few hours after being cast. This subject of finish of concrete is one that is becoming of more and more importance. On the so called "monolithic" structure where the forms must be left on for weeks after the members are cast, it is extremely difficult to finish the surface except by the expensive process of cutting or the unsatisfactory method of plastering.

The exposed surface of the Unit members can be given a variety of treatments, and by the proper selection of aggregates the appearance can be made as artistic as cost will allow.

The unit method also has another advantage in the speed in which buildings can be erected. This is often a very valuable consideration where replacements are being made, or construction on property

the producing power of which is lost during the time it takes to build a new structure.

The first development in separately moulded concrete units was in the form of floor sections to take the place of ordinary "monolithic" concrete or terra cotta between steel beams.

Floors of this kind have been on the market for some time and you are doubtless quite familiar with their general details and development.

It has been conclusively proven by the result of tests made on these factory floor sections that the usual working stresses which

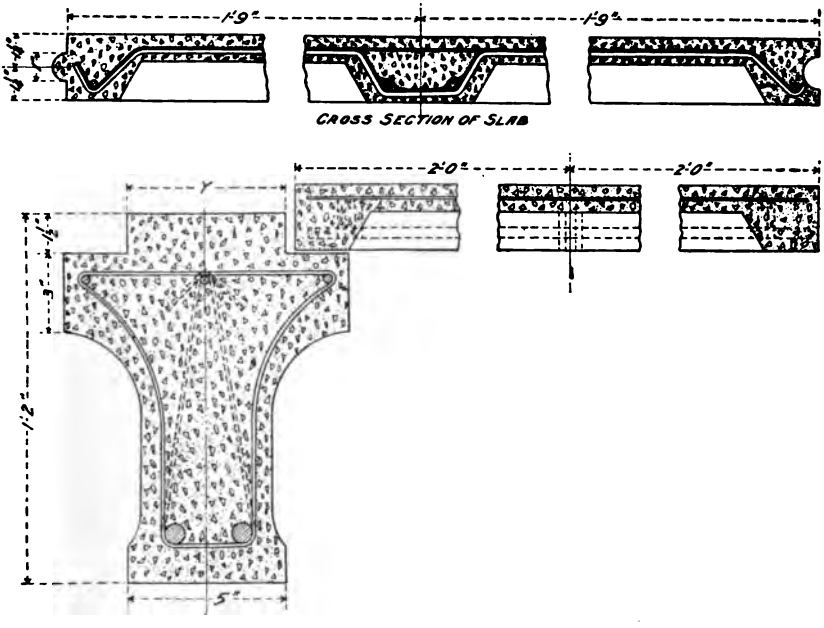


FIG. 1.

are used for the design of structures where field concrete is to be used should not be made the legal requirements for design when factory made concrete is to be used. Where the concrete is made in the factory under conditions which insure a uniform product that at the age the member is to be used will have an average compressive strength of at least five thousand pounds per square inch, and which is subject to regulation by actual physical test of the members

before use, a working stress of five hundred, or even seven hundred and fifty pounds per square inch is obviously absurd.

Fig. 1 shows the details of a type of floor construction designed by the writer and manufactured by the Onondaga Litholite Co., Syracuse, N. Y., for various buildings in Central New York. The plant of this company designed for the manufacture of a high grade artificial stone was admirably suited for a complete demonstration of the possibilities for factory made structural concrete, they having their own crushing and screening machinery and

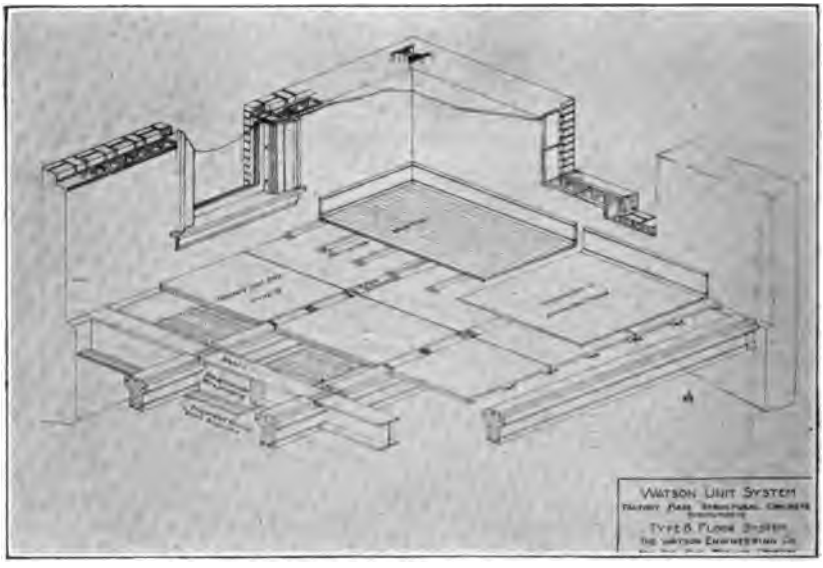


FIG. 2.

arrangement of storage, so that at least three sizes of aggregate could be used in proportioning concrete, and the aggregate itself being selected for its particular value for making structural concrete. As shown in the illustration, the design of the floor consists of floor beams with intermediate slabs, the floor beams being made in a combination of metal and sand moulds, the particular value of which for producing strong dense concrete has long been well known by the profession, and the slabs being made by the vibratory process of packing concrete, a method which is by no means

new, yet producing remarkable results as regards strength and density of concrete.

Fig. 2 is a perspective drawing showing the application of this unit beam and slab type of construction.

Fig. 3 shows a factory floor having a 19′ 0″ clear span designed for 150 lb. live load, having sustained a test load of six hundred pounds per square foot with inappreciable deflection and having an actual dead weight of only forty lbs. per square foot.

FIG. 3.

Fig. 4 illustrates as chool building at Kenwood, N. Y., where similar floors were used. This structure was built with a structural steel frame using terra cotta curtain walls and unit concrete floors, the floors having a clear span of 25′ 0″. All exposed structural steel was properly fireproofed, making a strictly fireproof structure throughout, and although the members were shipped nearly fifty miles by rail from the factory and then teamed nearly ten miles to the site of the building, it was constructed at the remark-

FIG. 4.

FIG. 5.

ably low cost of less than fifteen cents per cubic foot. The interesting feature on this work was the design of the roof beams. Instead of building a flat roof as is customarily done in concrete construction, with cinder fill on top to give proper drainage, the roof beams were made with the top flange on a slope so that when the slabs were laid in place it gave proper drainage to one point.

One of these beams is shown in Fig. 5, together with one of the 6′ 0″ standard floor slabs.

Fig. 6 shows a gang of these 6′ 0″ slabs being dismantled after having been removed from the vibrating machine. It is interesting to note that these slabs were made on end, about a thousand square feet of floors in each gang, and that the vibratory process completely fills this form, although the section in some cases is less than 1″ and obstructed by a relatively large amount of reinforcement.

The reinforcement of these slabs is specially designed to permit of very quick assembling and the prevention of any movement of the steel in the forms during vibration.

While the foregoing views illustrate the development in Unit Structural Concrete made possible by permanent concrete factories, such development has been limited almost exclusively to floor members on account of lack of equipment for handling larger units. There has, however, been a general development of unit methods in field construction for all, or practically all, the members of a building to be manufactured at or near the site and erected much like structural steel or mill construction. While the conditions under which these structures are built of field made units are not such as to produce the results obtained in factories, it is only a matter of volume of demand before permanent factories will be established, making this possible.

The reader is doubtless already familiar with most of the preliminary work of this kind executed in America, among which are the Textile Machine Works at Reading, Pa., built under the Visintini system by the Concrete Steel Co. of New York, the kiln house of the Edison Portland Cement Co., built in 1908, a car barn at Harrisburg, Pa., built by Mason D. Pratt, and the work of Ernest L. Ransome, C. E., for the United Shoe Machinery Co., at Beverly, Mass.

In 1908 the speaker employed the unit system in the design of a factory at Syracuse, N. Y., employing Unit methods under rather

peculiar conditions in that the building had to be built on filled ground on which piling was impractical and where unusual settlement was expected. The structure was designed as an articulate skeleton with bolted connections quite similar to what would be designed for timber, and is interesting on account of the unusual length of the roof beams which were 44′ 0″ over all, having a clear span of 41′ 6″, weighing about 6½ tons.

FIG. 7.

Fig. 7 is a view of this plant during erection.

The largest demonstration as regards amount of work executed and perfection of details in the unit method of construction has been made by the Unit Construction Co. of St. Louis, Mo., who have been actively engaged in this form of construction for the past five years, during which time they have built many structures of various types throughout the country, having under construction this season alone buildings containing no less than forty acres of floor space.

This company, who controls practically all the patents issued on unit concrete construction, employ the unit system on practically all the members of the building, including walls, columns, and even

skylights. Buildings as high as six stories have been successfully constructed and a complete demonstration made of the practicability of the system to high, as well as low, structures except, perhaps, for a slight difference in cost of equipment for erection.

FIG. 8.

Fig. 8, being a view of the office, oil house and stable of the National Lead Co. at St. Louis, Mo., illustrates the general application and appearance of their typical Unit structures.

Fig. 9. The Ohio Cultivator Works, Bellevue, Ohio, under construction, illustrates the typical details of the interior members and general method of erection.

Fig. 10. The National Enameling and Stamping Co. at Granite City, Ill., illustrates the general interior appearance of a completed unit constructed factory. It will be noted that the principle of design in these connections is quite identical, that is sufficient steel is exposed at the joints so that when the field concrete or grout is poured in there is sufficient bond between the field concrete and the steel to take care of all necessary stresses.

FIG. 9.

FIG. 10.

Where concrete wall slabs are used these are made to span from column to column and held in position by slots cast in the column.

FIG. 11.

Fig. 11 is a view showing the placing of one of these wall slabs.

FIG. 12.

Fig. 12 shows the method of splicing the column. It will be noted

that the column is held in position by means of the clamp, permitting the proper overlapping and exposure of the steel to be grouted in

FIG. 13.

FIG. 14.

at the joint, the clamp being removed when the field concrete has properly set.

The field equipment for manufacture, handling and erection of these members is a very important factor.

The spouting system is quite generally employed in the manufacture, using a specially designed concrete distributing tower illustrated in Fig. 13.

The members are taken from the yard to the site of the building by locomotive cranes, the crane removing the members from the

FIG. 15.

form and placing them on flat cars for delivery to the erection derricks.

FIG. 16.

FIG. 17.

Fig. 14 shows a trainload of these units being delivered at the site of one of their jobs.

Fig. 15 shows one of their standard erecting cranes.

Some of the largest contracts which this company have under construction are that of the Post Textile Co., at Post City, Texas, the exterior of which is shown in Fig. 16, and the interior in Fig. 17. This plant has a floor area of five acres.

FIG. 18.

Fig. 18 shows one of the eighteen 42′ lattice type girders which were used on this structure.

Another large factory, just completed, is that of the Sturgis Burn Co., at Melrose Park near Chicago, the ground area of this plant being about five acres.

Fig. 19 shows the ground plan and Fig. 20 the typical section of this plant.

Fig. 21 shows a grain elevator built at Hammond, Indiana.

Figs. 22, 23, 24 show exterior and interior views of a round house for the Sante Fe at Riverbank, Cal.

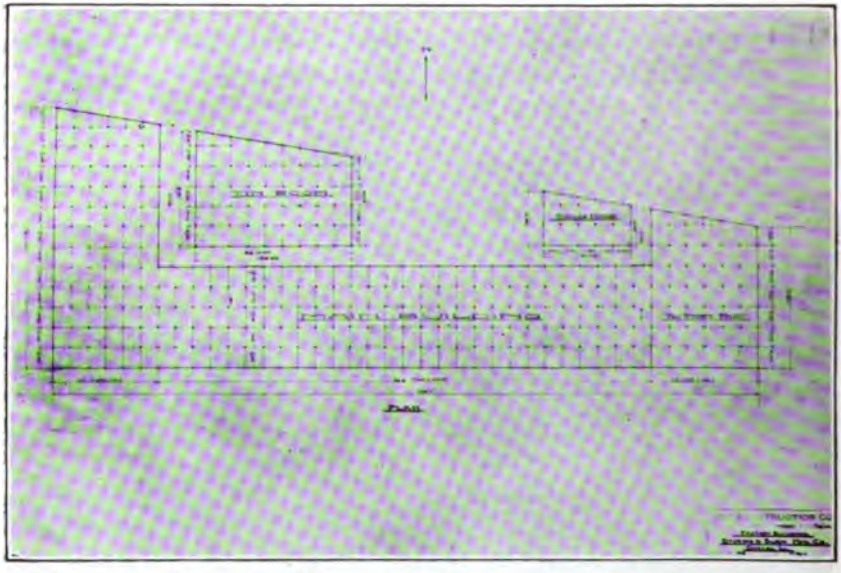


FIG. 19.

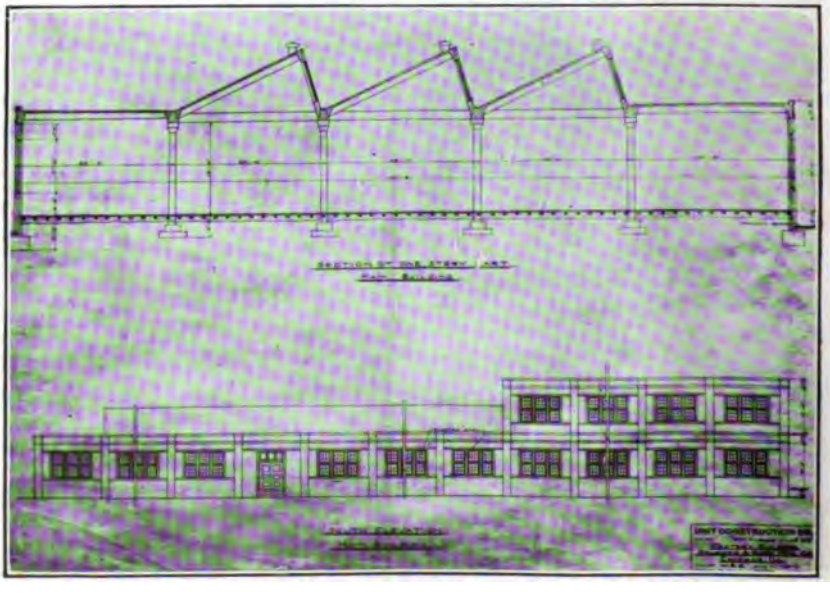


FIG. 20.

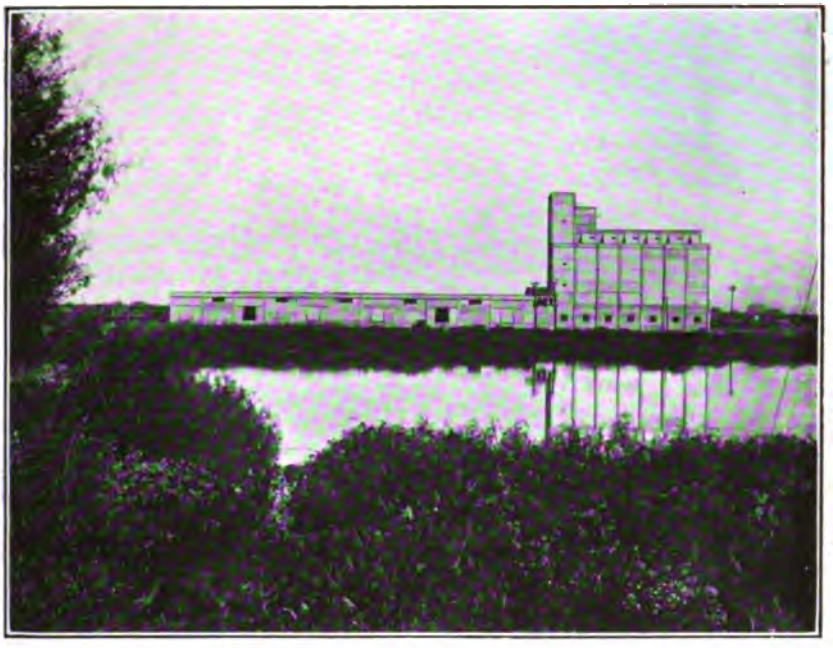


FIG. 21.

FIG. 22.

FIG. 23.

FIG. 24.

The largest plant which this company now has under construction is that of the Terminal Warehouse Co., at Memphis, Tenn., consisting of cotton warehouses covering about sixteen (16) acres of ground.

This company also has under construction at Philadelphia, a car house for the Philadelphia Rapid Transit Co., covering about five acres of ground.

This building was designed by the architects and engineers of the Philadelphia Rapid Transit Co. ,with the idea of using Unit

FIG. 25.

Methods and the design was only slightly modified to conform to the standard details of the Unit Construction Co.

There are ten 37′ 6″ bays, column spacing 16′ 0″, there being in all something over three hundred roof girders, each weighing between eleven and eleven and a-half tons.

Fig. 25 shows the casting yard of this job and a nest of girders after the forms were removed.

Fig. 26 ditto showing the columns.

Fig. 27 shows the start of the erection of this work, cranes, derricks and erected members in the background and the roof members and girders in the foreground.

FIG. 26.

FIG. 27.

PAPER NO. 1118.

SANITARY PROTECTION OF THE WATER SUPPLIES TAKEN FROM THE GREAT LAKES*

BY GEORGE C. WHIPPLE

Professor of Sanitary Engineering, Harvard University

Read November 2, 1912

More than five million people live in cities and towns near the shores of our Great Lakes. Most of these communities take their water supplies from the lakes and discharge their sewage into them. Except where the water supply has been purified before being used, this practice has very seriously affected the health of the lake cities and has been the cause of much loss of life. With our present sanitary knowledge it seems strange that such a filthy practice should have been ever tolerated. It is still more strange that raw lake water should continue to be used in cities which are doing so much in other ways to improve public hygienic conditions. The object of this paper is to set forth the problem in its various aspects, to show the effect of the use of raw contaminated lake water on the public health and to point out the ways in which the problem has been solved or may be solved under different local conditions.

THE GREAT LAKES.

The Great Lakes drain an area of nearly three hundred thousand square miles, of which about two-thirds is land area and one-third water area. The following figures show the relative magnitude of the various lakes:

---

* Read at the International Congress of Applied Chemistry, September, 1912.

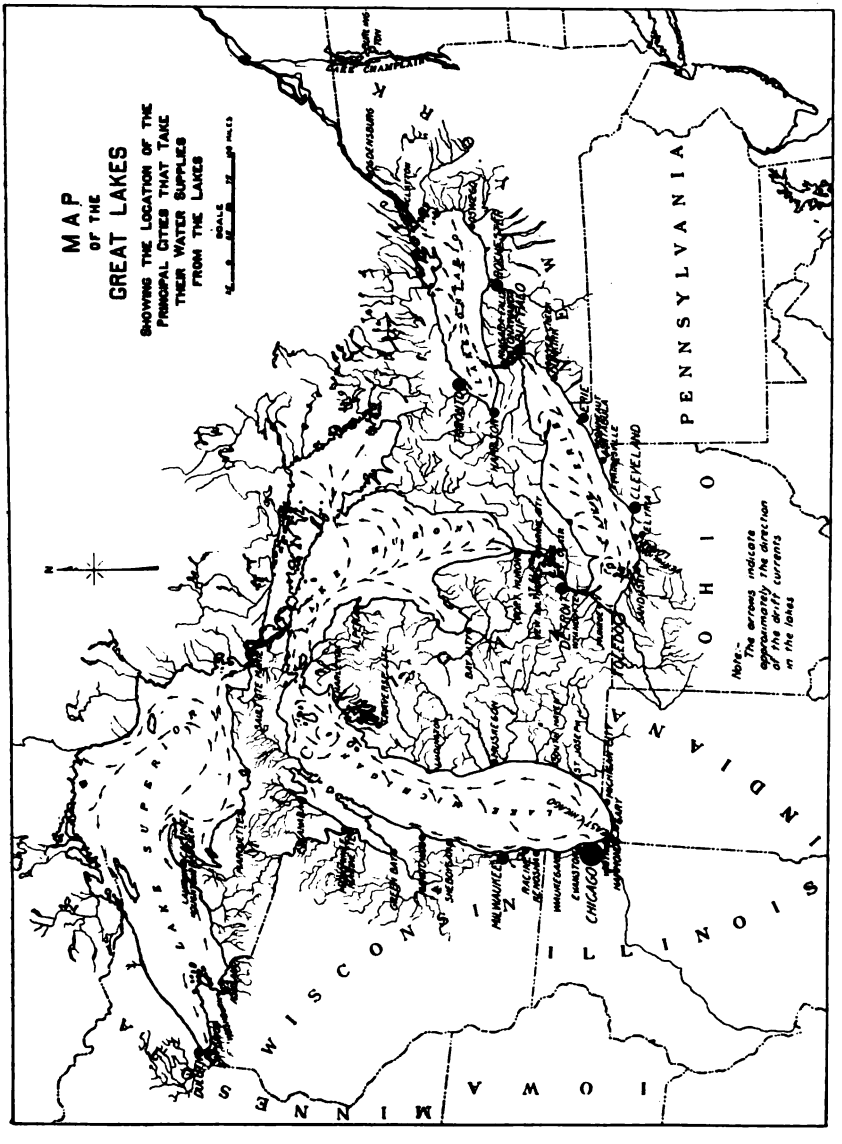
DATA RELATING TO THE GREAT LAKES.

LAKE.	LAND SURFACE.	WATER SURFACE, SQUARE MILES.	TOTAL.	MEAN ELEVATION ABOVE SEA LEVEL AT NEW YORK.	MAXIMUM OBSERVED DEPTH, FEET.
Superior	48600	31800	80400	602.28	1012
Michigan ...	45700	22400	68100	581.36	864
Huron	52100	23200	75300	581.41	750
St. Clair	6335	495	6780	.....	....
Erie	24480	9932	34412	572.62	210
Ontario	25720	7260	32980	246.2	738
Total	202935	95037	297972		

Lake Superior is the largest body of fresh water on the globe. According to the United States Lake Survey (Bulletin 14) "it is characterized by deep water, and high and rocky shores along a large portion of its coast. Compared with the other Great Lakes, its surface is more elevated above the sea; it is more irregular in outline, has deeper and colder water, more fog and ice, but less rain; the winds and seas are not greatly different from those of the other lakes." The major axis of the lake lies east and west. The lake discharges at its east end through the St. Mary's river into Lake Huron. The discharge at mean stage was measured in 1902 and found to be 60,600 c. f. s. Lake Superior has few large cities on its shores and for the most part these are widely separated. Lake Superior has a shore line of about 1,925 miles, of which about 925 miles are in Canada. Of the remainder about 185 miles are in Minnesota, 185 miles in Wisconsin and 630 miles in Michigan.

The major axis of Lake Michigan lies north and south, except that in the northern part it turns easterly. Its average depth is about 288 feet and its capacity 179 million cubic feet. Its elevation is about the same as that of Lake Huron with which it connects through the Straits of Mackinac. Its natural discharge is about 87,000 c. f. s. Lake Michigan also has an artificial outlet through the Chicago River, the Drainage Canal, the Des Plaines River and the Illinois River westward into the Mississippi River, through which the flow is between 6,000 and 7,000 c. f. s. at the present time. The east shore of Lake Michigan is sandy and the harbors are not good. On the western shore there are a number of better harbors, located usually at the mouth of some river. These rivers are for the most part small. Green Bay is an important arm

of the lake on the west side. The pollution problem at the southerly end of Lake Michigan is a more important one than elsewhere in the Great Lakes, as there are numerous cities along the shore relatively near together. Lake Michigan has no Canadian boundary.



Its shore line in the United States is about 1,470 miles, 905 miles of which are in Michigan, 450 miles in Wisconsin, 60 miles in Illinois and 55 miles in Indiana.

Lake Huron lies northwest and southeast. It discharges into Lake St.Clair through the St. Clair River, the discharge at mean stage being about 212,000 c. f. s. Georgian Bay is an important arm of the lake on the east side. Lake Huron is relatively unimportant from a water supply standpoint, as there are few large cities along its shores. It has about 1,900 miles of shore line, of which 1,320 miles are in Canada and 580 miles in the State of Michigan.

Lake St. Clair is a relatively small body of water through which a twenty foot channel has been dredged. It discharges into the Detroit River, which in turn flows into Lake Erie. It has only about 155 miles of shore line and no large cities are situated upon it.

Lake Erie is the shallowest of the Great Lakes. Its average depth is only 63 feet and its maximum depth 210 feet. Its capacity is about 17,500,000 cubic feet. Its axis lies east-northeast and west-southwest. Ordinarily calm, it is easily influenced by the high winds, which raise dangerous seas. Lake Erie discharges through the Niagara River into Lake Ontario. The discharge over Niagara Falls at mean stage is said to be about 227,300 c. f. s. There are a number of relatively large cities along the southern shore of Lake Erie, but most of these are widely separated. The shore line of Lake Erie is about 820 miles long. Of this about 340 miles are in Canada, 45 miles in Michigan, 290 miles in Ohio, 65 miles in Pennsylvania and 80 miles in New York State.

Lake Ontario, the last and smallest of the chain of Great Lakes, except Lake St. Clair, lies nearly east and west. It is comparatively deep, and accordingly the fluctuations of level are relatively less than on Lake Erie. It discharges into the St. Lawrence River, the discharge at mean stage being about 270,000 c. f. s. The capacity of the lake is about 450 million gallons. There are relatively few large cities located on Lake Ontario, the most important one being Toronto, Ont. The total shore line of Lake Ontario is about 980 miles, of which 600 miles are in Canada and 380 miles in New York State.

Quality of the Broad Waters of the Great Lakes.

Generally speaking the water of the Great Lakes away from the shores is of excellent quality for the purposes of a public water

supply. It is rather hard, but is softer than most of the water supplies taken from streams or from the ground in the same general catchment area. Lake Superior water is somewhat softer than that of the other lakes. This is shown by the following figures taken from a report by R. B. Dole on the Quality of Surface Waters in the United States (U. S. G. S. Water Supply Paper No. 236).

ANALYSES OF GREAT LAKE WATERS.

	Lake Superior at Saulte Ste. Marie.	Lake Michigan at St. Ignace	Lake Huron at Port Huron.	Lake Erie at Buffalo	St. Lawrence River at Ogdensburg.
			Parts Per Million.		
Total dissolved solids	6.0	118.0	108.0	133.0	134.0
Turbidity	.2	tr.	tr.	41.0	4.5
Silica (SiO^2)	7.4	10.0	12.0	5.9	6.6
Iron (Fe)	.06	.04	.04	.07	.05
Calcium (Ca)	13.0	26.0	24.0	31.0	31.0
Magnesium (Mg)	3.1	8.2	7.0	7.6	7.2
Sodium and Potassium (Na and K)	3.2	4.7	4.4	6.5	6.3
Carbonate radicle (CO^3)	0.0	2.9	1.8	3.1	2.9
Bicarbonate radicle (HCO^3)	56.0	112.0	100.0	114.0	116.0
Sulphate radicle (SO^4)	2.1	7.2	6.2	13.0	12.0
Nitrate radicle (NO^3)	0.5	0.3	0.4	0.3	0.3
Chlorine (Cl)	1.1	2.7	2.6	8.	7.7
			Per Cent. of Dry Residue.		
Silica (SiO^2)	12.7	8.5	11.11	4.5	5.0
Iron oxide (Fe^2O^3)	0.2	0.0	0.0	0.1	0.1
Calcium (Ca)	22.4	22.2	22.3	23.4	23.6
Magnesium (Mg)	5.3	7.0	6.5	5.7	5.5
Sodium and Potassium (Na and K)	5.5	4.0	4.1	4.9	4.8
Carbonate radicle (CO^3)	47.5	49.6	47.4	44.8	45.7
Sulphate radicle (SO^4)	3.6	6.1	5.8	9.8	9.2
Nitrate radicle (NO^3)	0.9	0.3	0.4	0.2	0.2
Chlorine (Cl)	1.9	2.3	2.4	6.6	5.9
			Parts Per Million.		
Total Hardness (Calculated from Ca and Mg)	45.4	99.2	89.2	108.2	107.5
Permanent hardness (Calculated from SO^4 radicle only)	2.2	7.5	6.5	13.5	12.5

The total hardness of Lake Superior water was 45, Lake Michigan water 99, Lake Huron water 89, Lake Erie water 108, and the St. Lawrence River water 107 parts per million. The permanent hardness likewise increased from about 3 parts per million in Lake Superior to 13.5 parts per million in Lake Erie. These figures correspond well with other data published elsewhere in connection with the water supplies of particular cities.

The chlorine is slightly higher in Lake Michigan and Lake Huron than in Lake Superior. It increases considerably in Lake Erie on account of the effect of the salt water from the oil well region of Ohio, which enters Lake Erie at the westerly end at various points between Toledo and Sandusky. In some parts of the lakes in the vicinity of these cities the chlorine in the water exceeds 10 parts per million; opposite Cleveland it ranges from 6 to 8 parts per million and at Buffalo it averages about 7 parts per million; in Lake Ontario it decreases slightly, presumably because of dilution.

The lake waters contain less than 0.1 part per million of iron.

The amount of organic matter in the broad waters of the lakes is very small. The waters have a very low color, usually less than 10, and are practically tasteless and odorless. Occasionally slight growths of algae occur, but they are almost never troublesome, except when the water is stored in open reservoirs before use.

The numbers of bacteria in the broad waters of the lake are almost invariably small. The bacterial counts made on gelatine at 20° C. according to standard methods are normally less than 100 per cc. during the greater part of the year. In summer they are less than this. After periods of rain and high winds they increase somewhat.

Of the condition of the water at the bottom of the lakes where deepest, its temperature, its dissolved gases, etc., very little is known.

Quality of the Shore Water.

The water near the shores of the lake may be quite different in quality from that farther out. This depends much upon the character of the shore, the proximity and character of inflowing streams, the season of the year, the wind, and many minor factors. Generally speaking, the shore water is more turbid and contains larger numbers of microscopic organisms and bacteria than the broad waters of the lake, and what is more important, it is more likely

to be contaminated with sewage discharged either directly into the lakes or into streams that flow into them. In the vicinity of large cities, and especially when these are situated upon large rivers, the pollution of the shore waters is a very serious matter.

The turbidity of the shore water is caused in part by washings from the land and in part by disturbances of mud deposits that have already taken place in the lake. During the author's investigation of the water of Lake Erie in the vicinity of Cleveland, in 1904, samples of water were collected at various distances from the shore near the city where the lake was polluted and at some distance from the city where the pollution was relatively small. Weekly analyses made between June 8th and August 26th showed the following average turbidities at different distances from the shore, at a point four miles west of the city, where the lake was but little contaminated.

QUALITY OF LAKE ERIE WATER AT DIFFERENT DISTANCES FROM THE SHORE NEAR CLEVELAND.

DISTANCE FROM THE SHORE IN MILES.	DEPTH IN FEET.	CHLORINE PARTS PER MILLION.	TURBIDITY.	COLOR.	NUMBER OF BACTERIA PER CC.
1	40	6.5	23	11	731
2	44	6.3	17	8	957
3	48	6.1	11	9	661
4	54	6.1	10	7	378
6	57	6.2	8	5	465
8	60	6.1	7	5	219
10	66	6.1	3	3	197

Owing to the varying amounts of suspended matter carried the shore water commonly differs in appearance at different distances from the shore. The apparent color of the water varies from a dull brown to a deep blue. Not infrequently there is a series of well-defined color zones. This was strikingly illustrated at Cleveland on March 15th, 1904, when an extended series of observations was made. It was found that at that time there were four distinct zones of water of different color and these zones were defined with great sharpness. Near the shore and extending out to a distance of about 1.5 miles to a depth of 35 feet, the water had a dark brown color. Outside of this there was a zone one mile

wide where the water was of a light brown color. Beyond this was a zone two miles wide where the color was Nile green and still further beyond was the deep blue water of the lake. The turbidity of the water and the number of bacteria present in the different zones are shown by the following table:

QUALITY OF SHORE WATER AT CLEVELAND, OHIO, MARCH 15, 1904.

ZONE OF	DISTANCE FROM SHORE IN MILES.	DEPTH IN FEET.	TURBIDITY.	BACTERIA PER CC.
Dark Brown Water	0 to 1.5	0 to 35	25	2500 or more
Brown Water	1.5 to 2.5	35 to 45	15 to 25	1250 to 2500
Green Water	2.5 to 4.5	45 to 55	5 to 15	100 to 2250
Blue Water	4.5 to 6.5	55 to 65	5 or less	100 or less

It will be noticed that the turbidity varied from more than 25 in the dark brown water near the shore to less than 5 in the blue water, and that the bacteria decreased from more than 2,500 per cc. in the dark brown water to less than 100 per cc. in the clear blue water of the lake.

Similar variations in the turbidity and number of bacteria at different distances from the shore have been observed by others, and especially by those who have studied the condition of the lake water at the southerly end of Lake Michigan. For example, Barnard and Brewster in their study of the sanitary condition of the southern end of Lake Michigan, bordering Lake County, Indiana, between August 19th and September 27th, 1908, found the following numbers of bacteria present at different distances from the shore.

DISTANCE FROM THE SHORE IN MILES.	AVERAGE NUMBER OF BACTERIA, PER CC.
0 to 1	174,000
1 mile	15,000
2 miles	6,600
3 "	5,800
4 "	4,400
5 "	1,000
6 "	200

At Milwaukee the width of the zone of turbid shore water varies in different places, according to the profile of the bottom of the lake.

Generally speaking the wind does not stir the bottom deposits to any appreciable extent where the water is more than about 40 feet deep. Only with extraordinary wind velocities are the deposits disturbed at great depths. Undertow currents may carry turbid water out to considerable distances from the shore, and thus give a false impression of disturbances at greater depths. The effect of the shore wash and the disturbance of bottom deposits, taken in connection with the undertow currents, however, is so great that no water supply intake has yet been carried far enough from the shore to avoid the occasional drawing of turbid water.

One of the longest water supply intakes is that of Cleveland, which is four miles from the shore in 50 feet of water. Between February 15, 1904 and June 30, 1905, the following turbidity observations were recorded of water at the pumping station:

TURBIDITY OF LAKE ERIE WATER AT CLEVELAND, OHIO.

MONTH.	MINIMUM.	MAXIMUM.	AVERAGE.
February, 1904	10	20	15*
March, "	3	18	10
April, "	4	100	35
May, "	10	45	23
June, "	5	75	31
July, "	0	15	3
August, "	0	20	3
September, "	5	5	5+
October, "	5	30	9
November, "	5	90	28
December, "	10	100	40
January, 1905	5	90	22
February, "	4	5	4
March, "	3	30	5
April, "	4	50	8
May, "	4	20	5
June, "	0	7	2

EFFECT OF INFLOWING STREAMS ON THE QUALITY OF LAKE WATERS.

Many of the large cities of the lake are located at the mouths of rivers. This fact has an important bearing upon the quality of the local water supplies, for the streams are usually polluted with sew-

* Three observations only.

\+ Four observations only.

age and when the rivers are in flood their waters may be traced for a considerable distance into the lake. Not that these streams preserve their integrity through the lake waters, but rather that the river waters mix with and become diluted by the water of the lake, so that the latter become polluted over a fan-shaped area which varies in distance and spread according to the volume of the river and the wind currents in the lake. At times the effect of the river waters can be detected by the senses for several miles off shore. Thus at Cleveland the water of Lake Erie at the old intake, 1.5 miles from the shore, frequently had an oily odor, while with a strong off-shore wind the oily odor could be sometimes detected even farther out. It is said that at times it has been detected even at the new intake four miles from the shore. At the east of Lake Ontario at certain seasons the dark brown water of the Black River can be followed into the lake by its color for a number of miles.

Movements of the Water.

Before discussing the question of lake pollution it is important to consider the movements of the water in the lakes for upon them depends the manner in which the inflowing sewage is mixed with the water and dispersed. They may be discussed under the following heads: (1) Movements of Translation. (2) Drift Currents. (3) Seiches. (4) Vertical Currents (Temperature currents). (5) Local Wind Currents. (6) Undertow Currents.

Movements of Translation.

The waters of the lakes do not move as slowly flowing rivers toward their outlets, as these movements of translation are masked by the more active currents due to other causes. There is, of course, an outward flow, but the actual velocity of the water from this is extremely small.

Thus the cross-section of Lake Erie at Cleveland is about 20 million square feet and the quantity of water passing about 200,000 cubic feet per second, hence the theoretical easterly movement of translation is 36 feet per hour, or 0.16 mile per day. The capacity of Lake Erie is about 17,000,000 cubic feet, the discharge at Niagara Falls about 227,000 cubic feet per second; hence the storage in the lake represents the flow for about two and a half years.

In Lake Ontario the period of storage is still longer for the cubical capacity of the lake is 60,000,000 cubic feet, and the discharge

270,000 cubic feet per second. The lake thus holds as much water as flows through it in 7.3 years. Kuichling has calculated that opposite Rochester the discharge is 237,500 c. f. s. and the easterly movement of translation, 193 feet per day.

In Lake Michigan the storage is equal to the natural discharge in a hundred years, and in Lake Superior it is still greater.

Drift Currents.

In all of the lakes there are drift currents of the broad waters near the surface due to the resultant action of the prevailing winds. Near the shore these currents are modified by the contours of the shore and reflected currents or eddies are formed. There are also return currents or deep drift currents induced by the general drift of the water towards a shore. These drift currents have been somewhat carefully studied by the United States Weather Bureau and maps have been prepared on which the surface currents are shown by arrows which represent the results of observations of the paths of many floats.

At the southerly end of Lake Michigan there is a southerly drift of the water on the west side past Milwaukee and Chicago, and a northerly drift of the water on the east side. The reason for this is that the prevailing wind at Chicago is from the southwest (S. 53° W.) and at Grand Haven, on the east shore opposite Milwaukee, is more nearly towards the north (S. 39° W.). The surface water being thus driven easterly and northerly at the south end of the lake, causes an induced southerly drift at Milwaukee, where also the prevailing winds are northerly rather than southerly (N. 87° W.). The wind records at Milwaukee from 1900 to 1909 show that the winds blowing southerly exceed those blowing northerly by about 3,000 miles per year. This unbalanced wind movement sets up a southerly drift of the surface water. This results in a drift of perhaps half a mile a day, or 150 miles a year, if the travel of the surface water is taken, as it commonly is, at 5% of the wind movement. This drift would not be constant, for the wind at Milwaukee seldom blows without change from the north for a week at a time, and although the wind movement to the south is 3,200 miles a year more than that toward the north, the latter amounts to 25,600 miles per year and the former to 28,800 miles.

At Cleveland there is a large excess of wind movement from the west; that is, down the lake, which amounts to about 24,490 miles

per year, or an average of 67 miles per day. This excess occurs eleven months in the year, being greatest during the winter. If the surface water travels at the rate of 5% of that of the wind the average surface drift would be 3.35 miles per day, and the maximum in the winter, 7.5 miles per day. The drift currents are naturally less near the shore than in the broad waters of the lake .When they impinge on jutting points they are deflected—sometimes towards the shore forming eddies when there are well-defined bays, as for example, in Lake Erie near Lorain and Sandusky. These eddy currents have been studied only to a limited extent.

These general drifts of the surface waters are well known by navigators and fishermen, and advantage is taken of them in locating water works intake and sewer outfalls, so that the sewage will be carried away rather than towards the intake. This practice is good as far as it goes, but confidence in it has been in the past altogether too great and wholly unwarranted by the facts as they are now known. Two great factors have been left out of account—the drift currents are not constant, and the intakes are located at some distance below the surface and well within the range of the undertow currents.

When the winds drive the water to the end of a lake, the level of the lake is raised and the increased head causes a return current near the bottom or beneath the neutral axis. Relatively little is known of these deep return currents beyond fragmentary bits of evidence obtained by experience. For example, near the shore of Lake Ontario overturned boats with the spread sails acting as submerged boats have been carried westward against a strong wind blowing towards the east. Dead bodies have been carried westward against a general easterly drift of the surface water. Fishermen's nets at the bottom of Lake Erie have been found clogged with debris on the lower side. That such deep return drift currents exist, however, is a natural inference from studies of the undertow that have been made at various places.

Seiches.

Seiches are rythmic fluctuations in the levels of lakes near the shores that somewhat resemble tides. The wind blowing over a body of water tends to pile up the water on the lee shore and lower the water level on the weather shore. This continues until the wind has exerted its maximum force, after which the lake tends to

return to a state of stable equilibrium. When the wind ceases the water which has accumulated on the lee shore falls below the mean level of the lake, while the water at the other end of the lake rises. Thus a series of rockings of the water of the whole lake takes place, the water at either end rising and falling alternately until a condition of rest is attained or until another wind starts the movement anew. This phenomenon is the same as may be observed in a basin of water where the water is disturbed slightly, moving from one side to the other before coming to rest. Other factors than the wind tend to produce these oscillations of water level, namely, differences in barometric pressure at the two ends of a lake, and differences of the temperature of the water. The wind, however, is by far the most important element in the problem.

In the Great Lakes the changes in level, due to the seiches, are often of considerable magnitude. They were carefully studied in Lake Erie by Professor A. J. Henry of the United States Weather Bureau in 1900 and described in Bulletin J of the Weather Bureau Publications. The fluctuations in the relative level in the water of the level at Buffalo at the easterly end, and at Amherstburg, Ont., at the west end of the lake, were recorded by automatic gauges. Diagrams given in the report show that the surface of this lake is almost never at rest, but constantly rocks back and forth, the average time of oscillation being between fourteen and fifteen hours. These changes in level frequently amount to several feet, and in extreme cases to ten or twelve feet or even more. Ordinarily, when the wind velocity is less than twenty-five miles per hour, the differences in level are not greater than one or two feet.

The storm of September 12, 1900, with a velocity of sixty-five miles an hour for two hours, caused the water level at Buffalo to rise about six feet above its previous level, while at Amherstburg the surface of the water fell about two feet. Soon after the wind fell below its highest velocity, the lake level began to fall and continued to fall for nine hours, the amplitude of the oscillation being 7′ 2″ and the time being a little less than sixteen hours. Professor Henry states that "the wind effect of this storm appears to have been much the same as would have been produced by a quick, powerful blow on the lake surface. The water of the whole lake was set in motion about a nodal line, and continued to rock for several days, the amplitude of each oscillation being a little less than that of the preceding one." Seiches of small amplitude occur

even when the weather is not stormy, and in most of the large lakes minor fluctuations occur, the level of the lake rising and falling a few inches every ten, twenty or thirty minutes, as the case may be.

During the summer when the lakes become thermally stratified with a stratum of cold and relatively heavy water at the bottom and warm lighter water at the top, the seiches produced by the wind in the upper strata gradually transfer their motion to the heavier water beneath, so that this also acquires an oscillatory motion, the amplitude and period of which may be different from that of the surface seiche. These variable fluctuations tend to mix the water of the two strata in the region of the thermocline.

The seiches have an important influence on the undertow currents described beyond.

Seiche movements may occur both longitudinally and transversely at the same time, in fact, this is probably the rule rather than the exception. The period of the transverse seiche is shorter than the other, so that along the shore in the middle of the lake the slopes of the water surface take various directions according to the manner in which the crests of the seiche movements coincide In consequence of this diagonal currents may be set up along the shore, which change frequently in force and direction, and which apparently bear but little relation to the direction of the wind blowing at the time. This is of particular importance in explaining the nature of the currents that occur after the wind which produced the seiche has ceased.

Vertical Currents

The water of the Great Lakes show, in general, the same fluctuations in the temperature of the water at the surface and at depths below the surface, as have been so frequently observed in smaller lakes and reservoirs. That is, during the summer the surface water is warmed by the sun, while the water at the depths is cold and quiescent. The wind stirs up the water of the lake and keeps it thoroughly mixed for a number of feet down from the surface. In small bodies of water the depth to which this wind action extends is seldom more than twenty or thirty feet, but in the large, d ep lakes it is more. Observations made in Lake Erie at Cleveland, in 1904, showed that the lake water was stirred by the summer winds to a depth of about fifty feet, while observations made in

Lake Michigan in 1910 showed that the water was stirred to a depth of about sixty feet. Below the stratum within which circulation takes place, the temperature of the water changes rapidly and the region where this change occurs is known as the thermocline. Below the thermocline the bottom water in the middle of the lakes probably remains relatively quiescent for long periods, but for several miles out from the shore the lower strata move in and out and are seldom at rest.

The temperature of the water at the bottom of the Great Lakes during the period of summer stagnation is practically that of maximum density, i. e., 39.2° F. The author once measured the temperature at the bottom of Lake Champlain (396 feet) in June and found it to be 39.3°. Comparatively few observations of the temperature of the water at the bottom of the Great Lakes have been made, but they substantiate this statement. Recently observations in Lake Ontario near Rochester have shown that water of maximum density came within a mile and a half of the shore at a depth of forty feet.

During the winter the surface water is colder than the bottom water. The latter maintains its temperature at about maximum density throughout the year.

During the spring, as well as during the fall, there is a period when the water has an opportunity to circulate from top to bottom. In very large lakes this period is short, and whether circulation actually extends to the bottom is not known.

Besides the vertical circulation produced by the natural heating and cooling of the surface water and the action of the wind vertical circulation may also take place near the shore, due to the inflow of river water or sewage of a different temperature from the water of the lake. This sometimes has an important effect upon the manner in which these inflowing streams mix with the lake water.

Thermal stratification of the water in small lakes has an important effect upon the depth of the return currents above referred to, causing the back flow to take place above the layer of stagnant water. But in the Great Lakes the thermocline marks the dividing line between the upper and lower currents moving in opposite directions. It is an unstable thermocline and does not necessarily imply stagnation.

Local Wind Currents.

From the standpoint of the pollution of water supplies, the most important currents that take place in the lakes are the local currents produced by the movement of the wind from day to day. As the wind blows over the lake surface currents of the water are induced by it, and as the wind changes, these currents also change. Observations that have been made in Lake Erie, notably by Walter P. Rice, at Cleveland, in 1890, and by the Cleveland Water Department, in 1895, indicate that there is a fairly close relation between the wind movement and the movement of the surface water; the travel of the surface water being commonly from 4 to 6% of the wind movement and averaging about 5%. The movement of the water is less at depths below the surface, decreasing with the depth and presumably becoming zero at the neutral line, which recent studies in Lake Ontario have shown to be at mid-depth near the shore. Observations made in Owasco Lake, near Auburn, N. Y., in 1911, by Mr. J. Walter Ackerman and the author, showed that the percentage which the travel of the surface water was of the wind movement varied with the velocity of the wind, being 3.2% when the wind velocity was five miles per hour, but only 1.2% when the velocity was thirty miles per hour. These observations were, however, made in a lake of relatively small size.

The velocities induced by the wind are greater on the lee shore than on the weather shore.

In order to illustrate the effect of these local currents induced by the wind, let it be assumed that the wind has been blowing off shore for ten hours at the rate of twenty miles per hour in such a direction as to cause the water to flow from the sewer outfall towards the water supply intake, and let it be assumed further that the velocity of the surface water during this period was 3% of the wind movement. The surface water would, therefore, be carried six miles from the shore during the ten-hour period, a distance more than sufficient to carry it to the longest intake now in use.

In addition to the velocity of the surface water induced by the wind, it is important to know also the angle of dispersion. An attempt was made to measure this at Cleveland, in 1905. A group of floats was set adrift in Lake Erie, at a time when the wind was blowing at the rate of thirteen miles per hour, and the position of each float observed for several hours. In one experiment after the floats had traveled 2,500 feet, which was 4.7% of the wind move-

ment, they had spread through an angle of about 5°. In other experiments with higher wind velocities, the angle of dispersion was slightly less. At the present time no data exist showing the relation between wind velocity and the angle of dispersion. It varies widely according to the veering of the wind and may be as high as 30° or 60° more. After several days of variable winds the fan of polluted water may spread over a semi-circle.

Undertow Currents.

When the wind blows strongly towards a lee shore the raised water level that results causes an outward current of the water beneath the surface. This phenomenon has long been familiar to fishermen and bathers. It has not been fully realized, however, that the undertow currents sometimes extend for several miles into the lake and well beyond the ordinary water supply intakes. As a result shore water is carried outward and sewage contaminated water periodically enters the intake, and is pumped into the city mains. The best evidence of these undertow currents is obtained by a study of the temperature of the water at different depths, at different distances from the shore and of the temperature of the water drawn from the intakes.

Daily observations of the temperature of the water at Milwaukee and elsewhere during the summer have shown very great changes in the course of a few days. Thus at Milwaukee, the temperature of the water at the pumping was 68° on July 20, 1910; on July 23, it was 62°; and on July 27th, 52°. At Rochester, even more sudden changes have been noticed. For example, on August 8, 1912, the temperature of the water at the bottom of the lake at a point 6,000 feet from the shore, where the depth was forty feet, the temperature fell from 59° to 42° in eight hours, the surface temperature meanwhile remaining about 64°. Two days previous, at the same distance from the shore, the temperature of the water had been 63° at all depths. The drop in temperature followed a sudden change in the direction of the wind from on-shore to off-shore.

The data now at hand indicate that the dividing line between the incoming and outgoing water lies at about mid depth.

When the warm surface water is blown away from the shore and cold water flows landward near the bottom, not all of the bottom water flows in as far as the shore line. Some of it becomes mixed with the upper strata and returns to the lake before it reaches the

shore line. The extent to which this off-shore mixing takes place has not yet been determined by adequate studies.

The undertow currents are of great importance in connection with the dispersion of sewage. During the summer season the temperature of the sewage will be ordinarily not far from that of the surface water of the lakes. If the sewage is discharged at the bottom of a lake at a considerable distance from the shore, it is obvious that when the cold, deep water is flowing shoreward, the sewage will be warmer and lighter than the water into which it is discharged. The sewage will, therefore, tend to rise into the upper strata and be carried away from the shore by the outward surface current. When the warm shore water is going out at the bottom the sewage will enter water of approximately its own temperature and will have less tendency to rise and will be carried away from the shore by the outward bottom current. Thus during the summer the movements of the wind, whether towards or away from the shore, tend at most times to carry the sewage away from the shore rather than towards it.

Effect of Breakwaters.

When sewage is discharged back of a breakwater or a natural bar off the shore, the water back of it is protected from the undertow currents. An on-shore wind causes the sewage to be held back of the breakwater, while the lake water blown towards the shore turns at the obstruction and flows downward and outward. On the cessation of the wind, or its change to the opposite direction, the over-polluted water back of the breakwater flows out as a surface current and thus gives use to streaks of polluted water that may extend far into the lake.

A somewhat similar phenomenon is when streams discharge into a lake through wide channels of low slope. In these there is a similar checking of the current followed by a subsequent increased discharge.

Lake Pollution.

The principal sources of pollution of the lake water supplies are, first, sewage discharged directly into the lake along the water front. Second, sewage discharged into streams that flow into the lake. Third, sewage polluted mud dredged from rivers and harbors and dumped into the lake. Fourth, sewage sludge transported by ice from the shore outward. Fifth, fecal matter discharged into the lake from boats.

The danger of pollution of the water supply in any case depends upon the opportunities afforded for the commingling of the sewage with the water before it reaches the intake, and upon the natural purification that takes place in the lake.

Dispersion of Sewage in Lake Waters.

When sewage is discharged into a lake it mingles with the water and gradually becomes dispersed through it, the nature and extent of the dispersion being dependent upon the local currents induced by the wind. It is impossible to calculate exactly the dilution of the sewage at different distances from the sources of pollution, for there are too many unknown factors, but computations based on arbitrary assumptions are sometimes found useful in showing approximately the dilution that may be expected under different conditions.

For example, suppose that sewage is being discharged at a point off shore and is dispersed through a sector that has an angle θ; and suppose, for purposes of calculation, that the sewage mixes through the entire depth and that this depth is constant. Let Q stand for the quantity of sewage discharged in time t, let r = the distance traveled by the water, under the influence of the wind in the same time, i. e. let r be the radius of the sector; and let d be the depth. If D represents the dilution, then

After time t $$D_t = \frac{\pi r^2 d.}{Q} \quad \frac{\theta}{360}$$

After time 2 t $$D = \frac{3 \pi r^2 d}{Q} \quad \frac{\theta}{360}$$

After time nt $$D_{nt} = \frac{(2n-1) \pi r^2 d}{Q} \quad \frac{\theta}{360}$$

To apply this to a practical case, suppose that sewage is being discharged at the rate of 25 million gallons per day; that the depth of water is fifty feet; that the wind movement is 100 miles per day and the water travel 5% of this, or five miles per day; that the angle of dispersion is 5°; and that t is one minute. Then Q = 2320 cubic feet per minute and r = 18.3 feet per minute.

$$D_{nt} \quad \frac{(2m-1)x3.1416x18.3^2x50}{2320} \quad \frac{5}{360} = .315 \ (2N-1)$$

Suppose that the sewage contains 1,000,000 bacteria per cc. and the

water none. Then for different distances from the point of discharge the water would contain the following numbers of bacteria:

R	N	D	Bacteria Per cc.
100 feet	5.46	3.13	320,000
500 "	27.3	16.80	59,600
1000 "	54.6	34.1	29,300
2000 "	109.2	68.4	14,600
3000 "	163.8	103.0	9,700
4000 "	218.4	137.2	7,300
5000 "	273.0	171.5	5,900
6000 "	327.6	203.0	4,900
7000 "	382.2	241.0	4,200
10000 "	546.0	344.0	2,900
15000 "	819.0	516.0	1,900
20000 "	1092.0	669.0	1,500

For different angles of dispersion the following numbers of bacteria would be found at different distances from the point of discharge:

Distance From Point of Discharge in Feet.	Number of Bacteria Per cc.			
	5°	10°	30°	60°
100	320,000	160,000	53,000	27,000
500	59,600	29,800	10,000	5,000
1,000	29,300	14,700	4,900	2,900
2,000	14,600	7,300	2,400	1,200
3,000	9,700	4,800	1,600	800
4,000	7,300	3,700	1,200	600
5,000	5,900	3,000	1,000	500
10,000	2,900	1,500	480	240
15,000	1,900	950	320	160
20,000	1,500	750	250	125

Natural Agencies of Purification in Lake Waters.

In addition to the very great and rapid dispersion of sewage in the water of the Great Lakes, various other agencies tend to bring about its natural purification.

Sedimentation is a potent factor. Compared with streams the velocities of the water in the lakes are low, so that, except near the shore, the suspended matter settles to the bottom, leaving the upper

broad waters of the lake very clear. Sedimentation must always be considered, however, with reference to subsequent disturbances of the settled solids by currents. During long periods of quiescence, pathogenic bacteria are liable to natural death in an unfavorable environment.

According to the best available information, the germs of typhoid fever do not multiply in the waters of the lake, but rather disappear at rates that vary according to different conditions. Using approximate figures for the sake of illustration it may be said that after a week ninety per cent. of any typhoid fever germs that may enter one of the lakes will have died, and after a month, ninety-nine per cent. How long the most resistant germs can survive is quite unknown. A small number, sometimes termed the "resistant minority," doubtless remain alive for several months. They are able to live longer in cold water than in warm water, a fact that Houston has recently demonstrated by some interesting experiments.

Sunlight exerts a powerful germicidal action on the bacteria in the layers of water near the surface, but even in the waters of a clear lake the sun's rays rapidly lose their energy below the surface so that disinfection by sunlight is not a factor at depths greater than a few feet.

Very important, however, is the action of the microscopic organisms found in the waters of all the lakes and that comprise the "plankton." The biological cycle is wondrously complete. Particles of sewage solids are decomposed by bacteria; bacteria are consumed by the protozoa; protozoa are consumed by rotifers and crustacea and the latter are eaten by fish. Also the products of bacterial action on the dispersed sewage, such as nitrates and carbonic acid, furnish food for the algae, such as floating diatoms and various chlorophyceae, and these in turn furnish food for the crustacea and larger organisms.

The oxygen resources in the Great Lakes are so enormous that except very near to the sources of pollution the lake water is saturated with dissolved oxygen. The complete destruction of the organic matter of the sewage by oxidation is, therefore, the ultimate fate of all sewage matters that enter the lakes.

Observed Contamination of Lake Water by Sewage.

Systematic analyses of the lake water in the vicinity of

Milwaukee, Chicago, Cleveland, Toronto and Rochester have given results not inconsistent with computation similar to the preceding. In general, they have shown that the dilution of sewage discharged into the lakes is ordinarily very great. It is, however, very variable and under certain conditions that occur several times each year, the sewage is projected through the lake water for several miles with relatively little dilution. When the path of this sewage stream lies in a direction from the sewer outfall to the water works intake, contamination of the water supply may and does occur.

The analyses that have proved most serviceable in the study of this problem are the following: (1) Number bacteria per cc. (2) Test for B. coli. (3) Turbidity. (4) Odor. (5) Chlorine.

The relative sensitiveness of these determinations varies according to the nature of the sewage. Ordinarily, the bacterial tests are the most sensitive, but not infrequently the simple odor test is equally satisfactory.

As an illustration of the observed contamination of lake water by sewage, mention may be here made of the studies conducted by the Milwaukee Sewerage Commission during the summer of 1910.

The sewage of Milwaukee, which then amounted to about 60 million gallons per day, is practically all discharged into the lake at the mouth of the Milwaukee River. Thence it spreads outward through the lake water and covers a fan-shaped area, becoming diluted as it leaves the shore. The water at the mouth of the river was found to contain very large numbers of bacteria, the average being 1,268,000 per cc., the minimum 525,000, and the maximum 2,600,000 per cc. The following figures show the observed numbers of bacteria at different distances from the shore along a line extending outward into the lake from the river mouth.

AVERAGE NUMBER OF BACTERIA IN LAKE MICHIGAN WATER AT DIFFERENT DISTANCES FROM THE SHORE OPPOSITE THE MOUTH OF THE MILWAUKEE RIVER

LOCATION.	BACTERIA PER C,C.
Mouth of River	1,268,000
1 Mile East of River Mouth	207,000
2 Miles " " " "	2,000
3 " " " " "	970
4 " " " " "	225
5 " " " " "	45

The water supply intake is about 3.5 miles in a straight line northeast of the river mouth. Here the average number of bacteria was 1,182 per cc. at the surface and 693 per cc. at the bottom, the largest numbers being 3,720 at the surface and 1,600 at the bottom, and the smallest numbers being twenty at the surface and fifty at the bottom. Generally speaking, the bacteria were higher at the surface than at the bottom, but sometimes the opposite was the case.

The observations of the Commission covered samples of water collected at intervals of one mile along a series of lines one mile apart from the shore outwards for three or four miles. Several series of samples were collected with the wind blowing in different directions. The results showed what would be naturally expected that the greatest amount of pollution could be traced in the direction towards which the wind was blowing. At times the axis of greatest pollution extended in a northeasterly direction towards and beyond the intake. At other times the course of the sewage was southerly.

Tests for B. coli were made on all of the samples of water collected, and estimates made of the average number present at each station. Thus at the mouth of the river the estimated average number of B. coli was 847 per cc. The numbers decreased outward from the shore, until at a point five miles from the shore the water contained less than one B. coli per cc. At the intake of the water works, the number was 2.1 per cc. at the surface and 0.4 per cc.at the bottom.

A study of the B. coli tests showed in a striking way the effect of the on-shore winds in causing the polluted water to pass out into the lake at the bottom and the effect of the off-shore winds in causing it to spread out over the surface. Thus, taking all of the samples collected at points more than a mile away from the shore, it was found that when the wind was blowing towards the shore the bottom water contained four times as many B. coli as the surface water, but that when the wind was blowing off shore the surface water contained eight times as many B. coli as the bottom water.

The effect of the sewage of the city on the bacterial character of the water at the intake and the variations from day to day are shown by the following daily analyses:

DAILY ANALYSIS OF WATER AT THE NORTH POINT PUMPING STATION

DATE 1910	HOUR P. M.	TEMPERATURE FAHR.	TURBIDITY	COLOR	ODOR[1]	CHLORINE	BACTERIA PER cc	TEST FOR B. COLI. 0.1 cc	1.0 cc	10. cc
Sep. 21	4:50	57.8	2	2	1v	4.0	2000	0	+	+
22	3:55	58.0	2	3	1v	4.2	1500	0	+	+
23	4:05	58.3	6	9	2v	4.0	1270	+	+	+
24	4:10	58.1	14	4	1v	4.5	1310	+	+	+
25	5:00	57.9	6	2	1v	4.2	1270	+	+	+
26	4:45	58.0	12	7	3d	4.2	1940	+	+	+
27	3:55	57.9	4	2	2m	4.0	2065	+	+	+
28	2:50	57.8	7	4	2v	4.0	1820	+	+	+
29	4:25	57.8	4	3	1v	4.0	1750	+	+	+
30	4:10	57.0	..	..	..	...	1100	0	0	+
Oct. 1	4:20	57.1	5	4	1v	4.2	3000	+	+	+
2	...	....	..	..	..	...	....	...	...	...
3	4:00	53.2	6	2	1v	4.0	2300	+	+	+
4	3:30	52.5	6	3	1v	4.8	940	+	+	+
5	1:58	47.0	4	4	1v	4.2	1250	+	+	+
6	3:50	56.5	10	4	2m	...	3500	0	+	+
7	4:40	56.0	7	2	2v	4.0	825	0	+	+
8	4:00	53.7	6	2	1v	4.2	1315	0	+	+
10	4:30	55.3	5	2	1v	4.2	1250	+	+	+
11	2:10	46.4	6	2	1v	4.0	500	0	+	+
12	3:40	53.4	20	4	1v	4.0	900	0	+	+
13	11:35*	54.3	15	4	1v	4.0	870	0	+	+
14	3:00	53.5	10	3	1v	4.0	345	0	+	+
15	5:20	54.8	4	2	1v	4.5	330	0	+	+
17	2:40	54.9	5	5	1v	4.0	5900	+	+	+
18	4:45	54.7	3	3	2v	4.2	800	0	+	+
19	12:05	54.1	6	3	1v	4.2	1200	0	+	+
20	4:20	54.5	15	4	2m	4.0	1215	0	+	+
21	3:55	54.0	10	3	2v	4.0	680	0	0	+
22	3:45	53.3	20	5	2v	4.0	1950	0	+	+
24	2:25	53.0	8	3	1v	4.0	2750	+	+	+
25	3:35	53.3	12	2	1m	4.5	1025	0	+	+

[1] 1v—very faint vegetable; 2v—faint vegetable; 2m—faint moldy; 3d—distinct, disagreeable.

CONTAMINATED LAKE WATER SUPPLIES AND THE PUBLIC HEALTH.

Stronger proof than that furnished by analysis is the effect of the use of contaminated water on the public health measured by vital statistics. A very complete study of the death-rates from typhoid fever and other diarrhoeal diseases in the cities that take

*A. M.

their water supplies from the Great Lakes has been recently published by Dr. Allan J. McLaughlin, in the form of two bulletins (Nos. 77 and 83 of the Hygienic Laboratory of the Public Health and Marine Hospital Service of the United States) entitled "Sewage Pollution of Interstate and International Waters with Special Reference to the Spread of Typhoid Fever." These reports describe the water supply and sewerage conditions in each of the lake cities and give tables of vital statistics compiled from local sources and from data gathered by the United States Census Bureau. The statistics are illustrated by many diagrams.

The case made out against the lake cities that do not filter their water supplies is a strong one. The typhoid fever death rates are shown to be very high as compared with European cities and with the cities of the United States that have safe water supplies. As an illustration of these high rates, the following table, compiled from the United States Census reports, is here presented:

Typhoid Fever Death Rates of Certain Cities Supplied with Water from the Great Lakes

(Data from United States Census Reports)

City.	Population 1910 Census.	Typhoid fever death rate per 100,000									
		1901	1902	1903	1904	1905	1906	1907	1908	1909	1910
LAKE SUPERIOR											
Duluth, Minn.	78,466	74.1	53.7	64.8	54.4	44.7	46.0	41.6	56.8	52.3	75.9
Marquette, Mich.	11,503	19.6	57.9	28.5	37.5	37.0	36.5	71.9	44.4	52.5	95.3
LAKE MICHIGAN											
Chicago, Ill.	2,185,283	29.8	45.1	32.1	20.1	16.5	18.3	17.7	15.3	12.6	14.7
Milwaukee, Wis.	373,857	22.1	15.1	16.8	13.6	22.7	30.5	25.7	17.4	21.2	45.7
Muskegon, Mich.	24,062	19.2	14.4	19.2	28.7	28.7	33.4	14.3	33.4	.....	24.8
Michigan City, Ind.	19,027	13.1	31.9	68.4	54.6	35.5	34.7	50.8	48.9	27.0	47.1
Marinette, Wis.	14,610	31.2	31.5	51.0	25.8	39.1	26.3	40.0	13.5	25.0	48.0
Escanaba, Mich.	13,194	50.3	67.8	28.0	351.4	182.8	101.1	120.2	126.5	230.0	60.3
Traverse City, Mich.	12,115	30.4	19.4	.....	35.6	25.7	90.5	23.8	53.6	29.6	24.7
Menominee, Mich.	10,506	56.5	25.1	86.8	117.2	46.9	78.2	91.8	64.0	54.5	66.7
LAKE HURON											
Bay City, Mich.	45,166	25.3	36.2	54.3	43.4	24.6	49.3	41.9	49.3	35.9	24.3
Port Huron, Mich.	18,863	41.3	61.2	25.2	34.9	14.8	53.8	43.5	19.1	52.1	74.4
Sault Ste. Marie, Mich.	12,615	92.9	172.9	115.9	52.4	68.6	58.9	16.5	72.9	56.1	23.7
LAKE ERIE											
Cleveland, Ohio	560,663	34.9	35.5	115.0	49.6	14.9	20.2	18.9	12.6	13.4	17.9
Buffalo, N. Y.	423,715	27.1	33.7	34.6	24.2	24.4	23.6	29.2	20.7	23.8	20.2
Detroit, Mich.	465,766	20.1	23.5	20.0	17.6	21.2	22.3	28.3	22.3	20.5	23.0
Erie, Penn.	66,525	16.7	25.4	33.7	48.6	17.0	48.3	78.4	62.5	29.0	38.9
Astabula, Ohio	18,266	44.9	36.3	49.4	137.1	60.0	38.9	19.0	86.2	42.0	43.6
Dunkirk, N. Y.	17,221	24.3	76.6	50.9	41.4	46.1	37.7	72.2	11.5	5.9	23.1
LAKE ONTARIO											
Toronto, Ont.	208,040*	17.8	14.3	18.2	25.8	18.7	31.4	.....	.....	.....	....
Niagara Falls, N. Y.	30,445	143.9	130.4	126.9	139.8	181.6	147.3	126.6	98.0	87.5	98.0
Kingston, Ont.	17,691*	39.0	5.5	99.5	22.1	38.5	38.4	.....	23.1	34.8	23.1

*Census of 1901.

Dr. McLaughlin points out that in the lake cities that use unfiltered water the typhoid fever death rate is exceptionally high during the winter season, thus affording additional evidence that this disease is more often transmitted by cold water than by warm water. He also shows that intestinal diseases classed as diarrhoea and enteritis, and infantile diseases are exceptionally prevalent in the lake cities that use unfiltered water and they too are liable to occur in the winter under the name "winter cholera."

In view of the completeness and accessibility of his reports, it is unnecessary to discuss this subject in detail.

Water Supply Intakes.

The lakes are the natural sources of water supply of the cities and towns near them, and in some instances they are the only possible sources. The land around the lakes is generally flat and no upland gravity supplies are obtainable. A few places, like Toledo, are supplied with water pumped from streams entering the lakes, but in most instances water of better quality and of unlimited volume is found in the lakes themselves. The fact that the supply is unlimited, or rather is limited only by the capacity of the pumps installed, seems to have encouraged a lavish use and waste of water, for we find that the per capita consumption of water in the lake cities has been high. The fact that the water is relatively cool in summer has, in some cases, developed a unique use of the water supply for cooling purposes. In recent years a number of unsuccessful attempts have been made to cut down the consumption.

The broad waters of the lake cannot be used for water supplies as it is not practicable to extend intake pipes or tunnels to points where the depth of water much exceeds 75 feet. The longest intake in use is that at Cleveland, which is 26,000 feet long and the end of which is about four miles from the shore. The Chicago intakes are from two to four miles long. The intakes at Milwaukee, Gary and Oswego are about a mile and a half long. There are several intakes about a mile long, namely, those at Bay City, Ashland, Kanawha, Sheboygan, Evanstown, Racine and Erie. Many of the intakes are shorter than this extending from 1,000 to 3,000 feet from the shore, and in some cases they are less than 1,000 feet.

Comparatively few intakes are located in water more than 50 feet deep. One of the deepest is that at Duluth, where the water is 75 feet deep and the openings in the crib 60 feet below the sur-

face of the water. The Toronto intake extends into water 68 feet deep, and it is proposed to extend it to water 100 feet deep. Oswego is constructing an intake in 83 feet of water. The Milwaukee intake is in 60 feet of water and the Chicago intakes are in from 27 to 40 feet of water.

The attempt seems to have been made in every case to extend the intake far enough to obtain relatively clear water and avoid pollution of the intake from local sewers. How inadequately the latter has been accomplished is shown by the typhoid fever statistics elsewhere quoted. Other considerations have been to have the intake in water deep enough to avoid a packing of the ice around the crib in the winter and to avoid the silting and clogging of the intake and pipe through movements of the sand. It has ordinarily been found desirable to have a depth of 20 or 30 feet.

The intakes at Cleveland and Chicago terminate in masonry cribs that extend above the water and are surmounted by light-houses. These cribs have entry ports at different depths. More often the intake pipes terminate in a submerged crib, or the pipe is merely turned up and supported by loose rock. Cast iron pipe has been largely used in the past, but steel is gradually taking its place. Tunnels are used at Chicago, Cleveland and elsewhere.

Many breaks have occurred in the lake intakes and a recital of the accidents would be interesting. In several notable instances, as at Toronto, these accidents have permitted polluted shore water to enter the pipes and outbreaks of disease have followed.

Methods of Protecting Lake Water Supplies.

The evidence is conclusive that natural methods of purification cannot be depended upon to protect the sanitary quality of the water supplies taken from the Great Lakes. Practically every city, whether great or small, that has depended solely upon the protection afforded by dilution and a supposedly remote location of the intake from the sewers has suffered from water borne diseases. As a rule, the smaller cities have suffered more than the large cities as their water supply intakes and sewer outfalls are nearer together. The visitations of typhoid fever have often been intermittent, and their failure to occur at regular seasons engenders a false sense of security; but sooner or later, when the necessary combination of currents and infection occurs, every lake city that fails to protect its water supply is bound to suffer from water-borne diseases.

Various expedients have been used at different times and at different places. At Chicago, after it became certain that its water supplies were subject to sewage pollution in different degrees according to the weather conditions the Health Department of the city inaugurated the policy of making daily analyses and issuing notices of the condition of the water in the daily papers, warning the people to boil the water or to cease using it for drinking in case the analysis was bad. This was many years ago. The practice may have had some beneficial effect, but it was placing dependence upon a frail reed. It had the inherent disadvantage that the quality of the water changed more rapidly than the analyses could be made and published.

A second method of protection would be to abandon the lake water altogether and substitute some other source of supply. This has been considered in some cities, as for example, at Toronto, where a gravity supply has been considered and rejected. Most of the lake cities are so situated that another source of supply is impracticable, or, in any event, costly, so this course has not been adopted and is not likely to be.

A third method is to extend the intake further into the lake. This has been done repeatedly. As the cities have grown the local pollution has become heavier and larger intakes have been required on account of greater water consumption. The effect of using longer intakes farther removed from sources of pollution has invariably improved the condition of the water, sometimes very noticeably. After a time, the water at the new intakes becomes contaminated so that the remedy is merely of temporary benefit. Then too, there is a limit to which this can be carried as the water off shore becomes too deep for economical pipe laying.

A fourth method would be to keep the sewage out of the lake. This is practically impossible, as the natural drainage of the lake cities is towards the shore. Ordinarily, no attempt has been made to keep the sewage out.

Chicago presents the only important instance where it has been accomplished and here it has not been accomplished in full. Situated at the south end of Lake Michigan and with only a low divide between it and the streams that flow westerly into the Mississippi River basin, and with this divide near at hand, it was possible to cut a canal through the divide, and turn the flow of the principal sewers into it, so that the sewage would flow westerly. This pro-

ject, known as the Chicago Drainage Canal, cost upwards of forty million dollars and entails a considerable annual charge for maintenance. A city of small size could not have financed so great an undertaking. The canal is so arranged that the Chicago River and its branches now discharge into it instead of into Lake Michigan; the lake water flows in at the old river mouth and dilutes the sewage, also turned from the lake into the river. The canal extends to Lockport, where the diluted sewage is discharged into the Des Plaines River, which flows into the Illinois River, this in turn flowing into the Mississippi River. The use of this canal lead to a notable suit in the United States Supreme Court, brought by the State of Missouri, acting in the interest of St. Louis, against the State of Illinois and the Chicago Drainage Canal District, which was settled in favor of Chicago.

This canal receives most, but not all, of the sewage of the city. In the southern part of the city there are large sewers that still discharge into the lake and pollute its waters. Projects are now in contemplation that will divert much of this sewage westward into the canal. It is recognized, however, that this method of diversion and dilution has a limit and that this limit will be exceeded before many years, so that projects are also being considered for the treatment of the sewage before it is discharged into the canal.

The Chicago Drainage Canal has very materially reduced the amount of typhoid fever in the city. It has not entirely prevented all pollution of the water supply. The large storm flows of the sewers still go into the lake and at certain times this may affect the water supplies from the various cribs. Furthermore, the accidental contamination of the lake water from so large a city with its shipping, its dredging operations, its industries located along the shore, is by no means a negligible factor. To protect the lake water against all these is a difficult task, except by filtration.

Protection by Sewage Treatment.

The next method of protection to be considered is the purification of the sewage before it is discharged into the lake. This has long received the attention of engineers and so much has been said about it in popular writings that the public has come to have faith in it. It is a plausible idea, and theoretically sound, but it has one fatal defect. To accomplish the purification of all of the sewage at all times demands works of excessive cost, while to partially

purify the sewage, or to fail to purify it at times of storm does not give the desired protection to the water supply. Nearly all large cities are sewered on the combined system, that is, the same pipes and conduits carry both house sewage and storm water. Purification works large enough for the treatment of all the storm water, as well as the house sewage, are almost never constructed, but overflows are provided to take the excess sewage at times of heavy rain. This storm overflow is merely the house sewage diluted and from a sanitary standpoint is dangerous. The storms that produce the overflow are likely to be accompanied by strong winds that create rapid and direct currents of the water in the lake, so that the method of protection by sewage treatment fails at those times when it is most needed.

The term "sewage purification" has been frequently used to cover methods of sewage treatment that only partially purify and that do not yield satisfactory effluents, considered from a sanitary standpoint. For example, it has been applied to screening, to sedimentation, to septic tanks, to chemical precipitation, to the use of contact beds, etc., processes which are often of great merit in their proper field, but which do not by any means convert sewage into drinking water, or into a liquid that can be safely mixed with drinking water. The misuse of the term "sewage purification" has thus led laymen to the belief that a lake water could be protected simply by "purifying" the sewage. The more recent use of the term "sewage treatment" instead of "sewage purification" should help to disabuse the mind of the public in this regard.

Treatment of the sewage of lake cities is often desirable in order to prevent objectionable conditions in the lake water near the point of discharge, and some form of treatment is likely to be adopted by nearly all of them. The nature of the treatment required will be usually governed by conditions other than the protection of the water supply. These treatments will, at the same time, somewhat reduce the danger of the pollution of the water supplies and will serve as an additional factor of safety. The point here emphasized is that in themselves, they are not sufficient to protect the water supplies.

The disinfection of the sewage by the use of chloride of lime has been suggested and if this could be carried out thoroughly the safety of the sewage effluent would be materially enhanced. The cost of disinfecting sewage, however, would be much greater than

the cost of disinfecting the water supply, so that, if disinfection were to be depended upon, the latter would naturally be preferred. The difficulty of disinfecting the overflow sewage at times of storm is another very great objection to this method. Used in connection with other forms of sewage treatment disinfection would further increase the factor of safety, but it ought not to be depended upon alone to protect the lake water supplies.

Disinfection of Lake Water.

If nature's methods of purification cannot be depended upon, if in the present state of the art an adequate purification of all the sewage is impossible of attainment, and if a partial treatment of the sewage does not suffice, the only course left is to purify the water supply itself. Fortunately this can be done satisfactorily and at reasonable cost. There are two methods of purification available for lake waters at the present time—disinfection and filtration.

The disinfection of the lake water supplies has been extensively practiced during the last few years. Among the larger cities where it has been used may be mentioned Toronto, Milwaukee, Cleveland, Erie and Niagara Falls. Chloride of lime, or bleaching, has been chiefly used, but at Cleveland liquid chlorine was tried with success.

The fact that the lake waters contain relatively small amounts of organic matter as compared with other surface waters enables disinfection to be accomplished by the use of small quantities of chemicals. For the same reason, the use of an excess of chemicals is readily noticed by the consumers on account of the disagreeable odor of chloride of lime that persists until the water reaches the service taps. Great caution is, therefore, required in the use of this method. If too little bleaching powder solution is added the disinfection will not be effective, while if too much is added the water will have a bad odor. The quantities of bleaching powder used have varied from six to eighteen pounds per million gallons. (10 pounds of calcium hypochlorite, containing 35% of available chlorine, per million gallons of water is equivalent to 0.42 parts per million of available chlorine.) Generally, the smallest quantity found necessary to give effective sterilization of the water has been six to eight pounds per million gallons. Quantities larger than about ten pounds commonly leave undecomposed hypochlorites in the water that may be detected by the consumers.

It is of the greatest importance to secure a prompt and intimate mixture of the bleaching powder solution with the water. This is not as easily accomplished as many think and requires a degree of skill in operation not easily obtained in practice. Failure to properly apply the chemical may easily escape knowledge of the authorities and such failure may be calamitous in its results.

That effective sterilization of the water can be obtained by this method is admitted by sanitarians; that it actually is obtained with practice is more doubtful. As an illustration of its results in a scientifically controlled plant the experience of Erie may be cited.

After the severe epidemic of typhoid fever that occurred in Erie during the first four months of 1911, a disinfecting plant was installed. During the first few weeks of operation, namely, from March 15 to April 25, the numbers of bacteria in the treated water did not exceed 50 per cc. and averaged only 7 per cc. During this period, from seven to ten pounds of bleaching powder per million gallons of water were used. Later, this was reduced to six to eight pounds. The average numbers of bacteria per cc. in the raw and treated waters during subsequent months were as follows: No. B. coli were found in the treated water.

Month.	Bacteria Per cc.	
	Raw Water.	Treated Water.
March, 1911	200	5
April, "	225	10
May, "	495	160
June, "	505	165
July, "	165	35
August, "	295	50
September, "	215	35
October, "	380	35
November, "	500	45
December, "	400	35

That the use of bleaching powder as a water disinfectant has reduced the typhoid fever death-rates in many places is probable, but its use has not been continued long enough to enable this to be measured with great certainty. That it does not completely protect against water-borne diseases is also probable. Thus, at Toronto, the water supply was disinfected before the recently con-

structed filter was put into use. During this period, it is said that the typhoid fever death-rate fell considerably below what it had been when untreated water was supplied, but after the filter was put into operation there was a further reduction of the death-rate, showing that disinfection alone had not furnished complete protection.

The method of disinfection of lake supplies ought to be looked upon not as a means of permanent protection of the quality of the water, but rather as a temporary or emergency measure. The uncertainties of operation are too great, the chances that not all bacteria are killed are too large to make this method one to be depended upon solely and permanently. And it is doubtful if the consumers will be long satisfied with water that may at any moment run from the service taps with an odor of chloride of lime. In the case of supplies that are only slightly contaminated it may be used to reduce still further the chance of infection, and thus, perhaps, postpone the time when filters are required, but such instances are few.

Filtration of Lake Water.

The best method of protecting the lake water supplies is to filter the water. This is more efficient than disinfection of the water and is very much cheaper than purification of the sewage.

Disinfection of the water does not remove any turbidity that may be present; filtration does. Disinfection does not remove any odor that may be present, due to algae; filtration, with aeration, does this, and while it is not often a matter of great moment, at times it may be of decided benefit. Therefore, although filtration costs more than disinfection, it gives more effective service and is more dependable.

Two methods of filtration are in use in the lake cities, sand filtration and mechanical filtration. These are now so well known that they do not need to be described. Suffice it to say that sand filters are operated at relatively low rates, say from two to six million gallons per day, and that mechanical filters employ a rate of about 125 million gallons per day. Sulphate of alumina, or some other coagulant, is employed with mechanical filters.

The choice of the two systems should be determined for each case according to the character of the water to be filtered, the availability of filter sites at proper elevation, and other local conditions. Generally speaking, sand filters are especially applicable to relatively

clear waters and mechanical filters to waters that are turbid for a considerable portion of the time. In general practice has followed this classification. Mechanical filters have been used by a number of the cities on the south shore of Lake Erie, as for example, Lorain, Elyria, Vermillion, Sandusky, Conneaut and Ashtabula. Here the intakes are rather near the shore and the water is somewhat turbid. A mechanical filter is now being designed for Evanston for the same reason, namely, that the shore water is turbid. At Toronto, on the other hand, where the turbidity is seldom high, a sand filter has been recently constructed and is now in operation. In a few instances, mechanical filters have been installed to purify relatively clear lake waters, namely, at Niagara Falls, on the Niagara River, and at Burlington, Vt., on Lake Champlain. Such filters are at a disadvantage from the standpoint of operation in that the attendant cannot as readily tell how the filter is working, for the reason that there is little difference in the appearance of the water before and after filtration. In the case of turbid or colored water, this difference is conspicuous, and failure to obtain perfect clarification is an indication of poor efficiency. Mechanical filters with clear waters have not been operated long enough to enable one to fairly judge of their success. It has been found that the quantity of alum necessary to be used with a mechanical filter operating on a clear water cannot be reduced much below ¾ grain per gallon without impairing the bacterial efficiency.

With clear lake waters the rate of sand filtration may be higher than in the case of other surface waters. The Toronto filter, for example, was designed for a rate of 6,000,000 gallons per acre per day, and when operated at this rate satisfactory bacterial efficiencies have been obtained.

Although sand filters cost somewhat more to construct than mechanical filters, this difference is not great and their cost of operation is less, so that when interest charges, operation and depreciation are all taken into account, the cost of the sand filtration may be less than that of mechanical filtration, while on the whole, the results are more dependable as less skill is required in operation. Good results, however, can be obtained by either method. Both mechanical filters and sand filters need to be faithfully operated and enlarged when necessary, in order that their capacity may not be overtaxed. Failure to do so may involve serious trouble. For example, the sand filter at Ashland, Wis. is said to have been over-

taxed to such an extent that filtration became imperfect and typhoid fever increased in the city. At Lorain, Ohio, faulty operation of the mechanical filter likewise caused an increase of typhoid fever in 1903.

In order to furnish an additional safeguard against infection of the water, it is becoming customary to provide for the disinfection of the water after filtration so that if for any reason the process of filtration has to be suspended, or if the bacterial efficiency falls below what it should be, hypochlorite may be used.

With the water supply filtered, expensive treatment of the sewage discharged into the lake is usually unnecessary. In fact, in some cases no purification may be required so far as the protection of the water supply is concerned. Treatment of the sewage, of course, gives an additional factor of safety.

The Problem a Local One.

The problem of protecting the water supplies of the lake cities is primarily and distinctly a local one. Each city is guilty of polluting its own water supply and each city is innocent of polluting the water supplies of its neighbors. There are perhaps a few minor exceptions and these are chiefly on the streams connecting the lakes. For example, the water supply of Detroit is somewhat polluted by the sewage of other places on the Detroit River, and the water supply of Niagara Falls is badly polluted by the sewage of Buffalo. As an example of a lake city that slightly pollutes the water of its neighbors may be mentioned Milwaukee, where the drift of the polluted water extends as far as Cudahy, but even the Cudahy supply is polluted more by its own sewage than by that of Milwaukee.

Each city also has the remedy in its own hands, namely, the purification of its own water supply.

At the present time there is no general pollution of the lake waters worthy of serious consideration and no general pollution problem is likely to arise for many years. The nearest approach to a general problem is at the southerly end of Lake Michigan where Chicago and a number of large cities are relatively near together.

Fearing lest a general pollution problem might arise in this region, and hoping to secure concerted action on the part of the lake cities to protect the quality of the lake water, the Lake Michigan Water Commission was organized in 1908. It is comprised of public health officials, engineers, water analysts and others from the states of

Wisconsin, Illinois, Indiana and Ohio, from the lake cities themselves, with representatives also from the United States Public Health and Marine Hospital Service. The Commission has held several annual meetings and its papers contributed have been helpful in stimulating the interest in the general problem.

In 1911 a more extended organization, known as the Great Lakes International Pure Water Association was projected and a temporary organization formed.

As sources of inspiration and as centers of scientific discussion, such organizations are of real service. But, inasmuch as each problem is a local one, it is difficult to see how concerted action can be or need be brought about. Nor does it appear that interstate or international arrangements are necessary in order to bring about local reforms. Scientific co-operation is needed much more than legal co-operation or the promulgation of general laws bearing on the subject.

The instances where the sewage of one city affects the water supply of another, as Detroit and Buffalo, or Milwaukee and Cudahy, are in almost every case contained within the limits of a single state. No international problems of water pollution of any great importance are likely to arise in the near future.

Nevertheless the United States Government can, through its Public Health Service, perform a useful service by bringing its influence to bear on individual cities, pointing out the dangers and recommending action where needed. Through its impartial position such recommendations carry weight. The power to compel action by the negligent lake cities naturally lies with the state in which the city is located rather than with the federal government.

It is evident from what has been said that some very important scientific studies need to be made to determine the laws that control the currents of the lakes and influence the dispersion of the sewage discharged into them. But it is not necessary to wait for such studies or to await further developments in the art of sewage treatment, as the obvious remedy for the protection of the lake water supplies is filtration of the water, with provision for its disinfection, if necessary. With the art of water purification so fully developed as it is, so thoroughly tested by experience, and proven to be reliable, no lake city can afford not to adopt this safe and sane method of protecting its citizens against the disease and death that lurk in sewage contaminated water supply.

DISCUSSION

MR. P. A. MAIGNEN.—Mr. Whipple is to be complimented for his excellent paper. We can never tire of hearing so clear an explanation of facts from one so well versed in his subject.

To enlarge the scope of the discussion I would like to ask Professor Whipple a few questions:

Will he tell us what, in his judgment, is the cause or modus operandi of the loss of free oxygen in water?

What is the influence on health of the presence in drinking water of the larger micro-organisms concerning which he has written so ably; and, is this influence exerted to the same degree in summer and in winter?

A few years ago, upwards of ten thousand analyses were made in the speaker's laboratory with Schuylkill water. The average count of bacteria in winter was 60,000 colonies per c.c. at the inlet to the settling reservoir at Lower Roxborough, which holds about 24 hours' supply. At the outlet the average count was 90,000 colonies. In the summer the inlet gave 6,000 colonies and the outlet 3,000. Here is a very interesting observation—a considerable increase in the winter and a still larger decrease in the summer. Surely this is a subject worthy of the most serious investigation.

Cold is supposed to check the growth of bacteria in water and here we have absolutely the reverse; in fact, the highest counts were found when there was a sheet of ice on the water. Sedimentation is supposed to purify the water. This seems to be true in the summer, but not in the winter. Why?

Is it because in the summer the larger micro-organisms or protozoa such as the parameciae, rotifers, volvox, and the like, are extremely lively in eating the small bacteria as big fish eat the little fish? In the winter the larger fellows seems to go to sleep, they are hardly to be seen anywhere in the water, so it would seem as if, at this time, the smaller bacteria had the field all to themselves:

I would like to ask Professor Whipple if he has ever observed this co-existence of the protozoa and bacteria in summer, and the absence of the former in winter.

I wish also to ask if any observation has been made as to the presence or absence of the protozoa in water known to have produced typhoid fever. These protozoa seem to be always present in water in which any kind of dead organic matter is undergoing decay, in fact they seem to be the chief instruments of the decay.

There are, as we all know, a considerable variety of protozoa. Some live a few months and others a few weeks. Some multiply so fast that very little room is left for any other kinds. Most of them are poisoned by the product of their own metabolism. If you want to keep them alive you have to give them fresh water and fresh food; if not, they die in their own juice; others die for want of appropriate food; whilst others again seem to live a considerable period of time on soluble matter. One rule is constant, if you give them fresh water you see them multiply very quickly. This would perhaps account for observations made with sewage. Dilution of water with sewage does not necessarily mean a lesser number of micro-organisms; on the contrary, the fresh supply of water seems to facilitate their multiplication.

I should also like to know what other diseases besides typhoid fever have been reduced by filtration?

I think the question of oxygen in water is an exceedingly interesting one. It reminds me of some observations which I have made for many years and as late as this afternoon. Place a drop of water infusion on a slide without spreading it, the drop will therefore be convex. If you focus the microscope so as to see the outer surface of the drop, you will see one kind of protozoa and one kind only; if you lower the microscope a little, you will strike another layer with another kind of micro-organisms, and finally if you reach the base, you will see some other species of protozoa and if there be any bacteria present, they are usually to be seen at the bottom. Some seek the air and go to the surface. It is perhaps of this kind that we speak when we say that the micro-organisms are aerobic. Others go to the bottom—I suppose these are anaerobic. Would it then happen that the free oxygen in water is appropriated by the protozoa which seek the upper layer of the water?

A last question: Would Professor Whipple tell us how often the typhoid bacilli has been found in water? It is, of course, cultivated in laboratories, but I understand it is seldom sought for in the water supply. Its cousin, the coli commune, is always sought as evidence of sewage pollution.

PROFESSOR WHIPPLE.—We believe it has been found a few times, but just how many I do not know.

MR. MAIGNEN.—Suppose a dead horse is thrown into the river, what are the kind of micro-organisms that will first appear on the scene to devour it? Any information on these different subjects would be very much appreciated.

MR. WEBSTER.—We are indebted to Mr. Whipple for his very interesting paper on the water supply of the Great Lakes and the movements of the currents which tend to carry pollution to water supply intakes, and also the discussion on the disposal of sewage by dilution. It is very evident that engineers are learning that the treatment and purification of sewage in this manner must be considered among the available methods.

It is now recognized that streams flowing through populated areas are unfit for water supply without purification and that the sewage of towns draining into such streams must be treated to an efficient degree, but not necessarily purified. By this I mean that the sewage must be treated to such an extent that it will not place an overload of organic matter upon a water purification works nor create a nuisance in the waters into which it is discharged. A great work will have been accomplished by any large city when its sewage is treated to such an extent that it meets these requirements.

It has been suggested that calcium hypoclorite would be useful in the treatment of sewage. It may be used to great advantage in certain cases as a protection to valuable shell fish layings or in time of epidemics, but for our large cities the cost of constantly treating sewage with hypoclorite of calcium would be prohibitive, and as a means of purification without any other treatment it would not give satisfactory results, as the chemical would disinfect the surface only of the large particles of organic matter and prevent the decomposition of the interior for a time, so that when these larger particles became broken up, decomposition would develop.

MR. S. M. SWAAB.—How far from the shore is that intake?

A. About 7,000 feet from the shore, and the intake is 40 feet below the surface.

DIAGRAM No. 2.—"When the wind was blowing toward the shore, the pure water was driven toward the shore. The temperature of that water was over 60°. In this case the tendency will be for the sewage to flow away from the shore rather than towards it.

PROF. WHIPPLE.—It is true that the larger forms of life thrive better in summer, and are therefore most likely to destroy bacteria in that season. It is a fact that we almost never have typhoid fever outbreaks in summer weather due to water infection. Such outbreaks nearly all occur in the fall or the spring when the weather is relatively cold. Some interesting facts have been learned in regard to the life of the typhoid bacilli. We have known for some time that these germs live longer in cold water than in warm water. Just why has not been found out, but the bacteriologists are beginning to employ statistical methods Starting with a known number of typhoid bacilli added to water, and observing how they decrease from time to time they have plotted the results on logarithmic paper and find that the points tend to fall on a straight line. That is the typhoid germs decrease in number logarithmically. The slopes of the lines are different for different temperatures, the disappearance being more rapid in cold water than in warm water Dr. Loeb, of the Rockefeller Institute finds two processes going on in natural life, processes of death as well as processes of life. The life processes are very materially increased by an increase in temperature; but the death processes are increased still more. On the other hand, as the temperature falls, the life processes are decreased somewhat, but the death processes are not increased as fast in proportion. And that explains —if we may call it an explanation—why it is that in the high northern latitudes, we find an unexpected abundance of microscopic life. The water there contains a great many more microscopic organisms than in the water farther south, because the death processes there do not take place as rapidly as the life processes. Just what these two processes are, I do not pretend to say.

As to some of the other questions that Mr. Maignen asked, I do not know that I can tell by name what other diseases are reduced by filtration, other than typhoid; but we do know that often when bad water is made good by filtration, not only does the death rate from typhoid fever decrease, but that the death rates from pneumonia and tuberculosis and other diseases that are not usually attributed to the water we drink also decrease.

MR. MAIGNEN.—You did not answer my question as to what is the cause of the loss of oxygen.

PROF. WHIPPLE.—I do not know that I can answer that except in a general way. Fish require a certain amount of oxygen, quite a large amount. I presume that most of you know by experience that when the children go away for the summer and leave the little gold fish in your charge, the fish usually die; not because of lack of care on your part, but because the little jar is too small to allow the absorption of sufficient oxygen from the air for the life of the fish. Microscopic organisms and some bacteria need a certain amount of oxygen.

MR. SWAAB.—The hypochloride can be used economically and to much better advantage on the water supply. Of course, there are times when the water

supply may fail, the mains may break; but in that case, I believe the precaution should be taken of having at hand means of treatment of the water supply. We cannot hope to get that protection from the sewage. This question of treatment of sewage is largely an economic one, and it is the duty of the sanitary engineer to take advantage of all those forces of nature that he has at hand. The great reforms that we looked for years ago are now, I think, practicable. Engineers are now speaking of "sewage treatment" and not sewage purification.

MR. VOGLESON.—I have been very much interested in what Professor Whipple has told us. If I remember correctly, he said that in the disinfection of water supplies, the practical results did not bear out the theoretical formulae. In the application of disinfection we run across a great many difficulties in regard to getting the service we desire, and I would like to ask if the difficulty in approaching the theoretical efficiency is not one which may be overcome by thoroughness in practical details.

PROF. WHIPPLE.—In regard to that, I would say that if the disinfectant is thoroughly mixed, and used in proper quantities there cannot be any question of its effectiveness, but I have seen many cases where it is impossible to get the intimate mixture that is necessary. You cannot discharge the solution through a pipe down into an aqueduct and expect to get a good mixture; sometimes it is necessary to resort to some special means to agitate the water and get the chemical thoroughly mixed. In so far as mixing fails, the process will fail.

ABSTRACT OF MINUTES OF THE CLUB

JOINT MEETING OF THE ENGINEERS' CLUB AND THE PHILADELPHIA CHAPTER OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, OCTOBER 5, 1912

The meeting was called to order by Vice President Plack at 8.35 P. M., with 72 members and visitors in attendance. The minutes of the business meeting of September 21st, were approved as printed in abstract.

Mr. George H. Perkins, of the Lowell Institute of Technology, spoke on the Exhibition for the Abatement of the Smoke Nuisance held in London in the spring of 1912.

Mr. O. R. McBride, of the University of Pittsburgh, read a paper, entitled, "Methods and Means of Smoke Abatement." The subject was discussed by Messrs. H. F. Morris, Chief Lukens, of the Bureau of Boiler Inspection, Mr. W. C. Furber, Dr. Howard S. Anders, Dr. Herman B. Allyn and others. On motion of Mr. E. S. Hutchinson, a vote of thanks was extended to Mr. McBride and Mr. Perkins.

REGULAR MEETING, OCTOBER 19, 1912

The meeting was called to order by Vice President Plack at 8.35 P. M., with 68 members and visitors in attendance. The minutes of the Joint Meeting of the Philadelphia Chapter of the American Society of Mechanical Engineers and the Engineers' Club, held October 5th, were approved as printed in abstract.

The Secretary announced that the following had been elected to membership by the Board of Directors at their regular meeting held October 17th, 1912: Active—G. Walker Gilmer, Jr., and Jonathan Jones; Junior—Fred M. Schilling and C. Carroll Sloan.

Mr. C. D. Watson presented the paper of the evening, entitled, "The Development of Separately Moulded Structural Concrete," which was discussed by Messrs. S. M. Swaab, John C. Trautwine, Jr., Edward S. Hutchinson and Prof. H. C. Berry.

REGULAR MEETING, NOVEMBER 2, 1912

The meeting was called to order by President Hess at 8.40 P. M., with 75 members and visitors in attendance. The minutes of the Regular Meeting of October 19th were approved as printed in abstract.

Professor G. C. Whipple presented the paper of the evening, entitled, "Sanitary Protection of the Water Supplies Taken from the Great Lakes," which was discussed by Messrs. P. A. Maignen, G. S. Webster, John C. Trautwine, Jr., S. M. Swaab, Wm. Easby, Jr., J. A. Vogleson, Prof. Whipple and others.

On motion of Mr. Trautwine, a vote of thanks was extended Prof. Whipple.

BUSINESS MEETING, NOVEMBER 16, 1912

The meeting was called to order by President Hess at 8.40 P. M., with 205

members and visitors in attendance. The minutes of the Business Meeting of November 2nd, 1912, were approved as printed in abstract.

The Committee on Nominations presented the following nominations for officers of the Club for the year 1913: President, W. P. Taylor; Vice President, S. M. Swaab; Secretary, E. E. Krauss; Treasurer, J. Reese Bailey; Directors, J. E. Gibson, Manton E. Hibbs, H. Clyde Snook, F. K. Worley.

The following were reported as having been elected to membership by the Board of Directors at their meeting of November 14th, 1912: To Active Membership—Harold Marcus Leh, John S. Ely; Junior Membership—Walter Stokes Fogg, Norman Dudley Fulton, Edward H. Robie.

Mr. Henry M. Neely presented the paper of the evening, entitled "The Mechanics of the Aeroplane," which was discussed by Messrs. E. G. Perrot, C. W. Bell, H. Goodwin, Jr., Carl Hering, W. C. Furber, S. M. Swaab and M. E. Reid.

On motion of Mr. Quimby, a vote of thanks was extended Mr. Neely.

Business meeting, December 7th, 1912:

Business Meeting, December 7, 1912

The meeting was called to order by President Hess at 8.35 P. M., with 97 members and visitors in attendance. The minutes of the business meeting of November 16th, 1912, were approved as printed in abstract.

Mr. B. A. Haldeman presented the paper of the evening, entitled, "The Planning of City Streets," which was discussed by Messrs. George S. Webster, H. H. Quimby, B. A. Haldeman, W. C. Furber, S. M. Swaab, Henry Hess, E. M. Nichols and H. M. Chance.

Business Meeting, December 21, 1912

The meeting was called to order at 8.35 P. M., by President Hess, with 100 members and visitors in attendance. The minutes of the Business Meeting of December 7th were approved as printed in abstract.

It was announced that the following were elected to membership at the meeting of the Board of Directors on December 19th: Active—J. Willard Gamble, Silas G. Griffith, Paul C. Haldeman, Allen S. Hurlburt, John J. Young, Jr.; Junior—Edward H. Blum, Chas. C. Campbell, Alexander P. Gest, Jr., T. Otto Mayer and David M. Niver.

The following additional nominations were presented:

For President, Mr. W. L. Plack, endorsed by Messrs. Joseph T. Richards, Frederick W. Abbott, Chester E. Albright, Walter Loring Webb, Henry L. McMillan, Alfred D. Morris, E. M. Nichols, Herman Livingston, A. M. Loudenslager, F. S. Crispin, J. Chester Wilson, Harrison Souder, John A. Carlisle.

For Director, Mr. H. M. Chance, endorsed by Messrs. Walter Loring Webb, Henry L. McMillan, E. M. Nichols, Herman Livingston, J. Chester Wilson, Harrison Souder, John A. Carlisle, W. Copeland Furber, Charles F. Mebus and J. Lawrence Hagy.

Mr. F. C. Robinson presented the paper of the evening, entitled, "Manufacture of Petroleum Products," which was discussed by Messrs. W. M. Irish, Wm. T. Price, John C. Parker, Henry Hess, S. M. Swaab, W. C. Furber, Carl Hering, and others.

A vote of thanks was extended to Mr. Robinson for his paper.

ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS

REGULAR MEETING, October 17th, 1912.—Present: President Hess, Vice President Plack, Directors Kerrick, Worley, Develin, Gilpin, Haldeman, Swaab, Yarnall, the Secretary and the Treasurer.

The Treasurer reported a net gain to October 1st of $854.04.

The following resignations were accepted: M. K. Bryan, George E. Dale, R. K. Matlock, L. A. Sagendorph, H. A. Rogers, Wm. R. Webster.

The President and Treasurer were authorized to negotiate a temporary loan for sixty days, the Finance Committee to recommend the amount.

The following were elected to membership in the Club: Active—G. Walker Gilmer, Jr., Jonathan Jones; Junior—Fred M. Schilling, C. Carroll Sloan.

Malcolm R. Maclean was transferred from Junior to Active membership.

Communications from the Water Conservation Association and the British Fire Prevention Committee were referred to the Committee on Public Relations for action.

REGULAR MEETING, November 14th, 1912.—Present: President Hess, Vice President Mebus, Directors Halstead, Kerrick, Gilpin, Vogleson, Haldeman, Swaab, Yarnall and the Secretary.

The Treasurer reported that C. F. Morrall had been dropped from the roll, in accordance with the By-Laws, on account of the non-payment of his initiation fee.

The following members were dropped from the roll for non-payment of dues: R. D. Allen, T. H. Boorman, E. Cunningham, Wm. McClellan, H. G. Perring, H. S. Righter, Wm. T. Ruth, W. A. Smethurst, J. Walter Ward and E. H. Wray.

The accounts of the above were ordered to be cancelled on the books, and listed in a special ledger.

The resignations of R. K. Sheppard, Philip L. Spalding, George L. Thompson, J. A. Colby, John Horridge, Wm. G. Bickell, Carroll W. Simon, F. K. Wilkinson, E. S. Morrell, M. Monaghan and W. K. Martin were tabled.

The report of the Finance Committee was read and approved, and the matter of the first mortgage referred back to the Committee, with instructions to renew the mortgage for a period of five years, if possible.

The Membership Committee's report was read and approved, and the following were elected to membership: —Active—Harold Marcus Leh and John S. Ely; Junior—Walter Stokes Fogg, Norman Dudley Fulton and Edward H. Robie.

The following Juniors were transferred to Active membership: G. L. Watters and Arthur C. Merrill; to Associate membership, T. Joseph Reilly.

The Committees on Publication, Meetings, Publicity, Advertising, Public Relations had no reports to make.

The report of the House Committee and of the Library Committee were read and approved.

The Business Manager's report was read and approved.

Owing to the fact that a legal quorum was present, on motion, all former actions of the Board were ratified.

A special sinking fund was authorized to be created for the purpose of liquidating second mortgage bonds and building notes, the conditions covering this sinking fund to be determined later.

The following changes in the rules for the government of the Board of Directors were adopted: Following the reading of the Minutes, "All resolutions and motions passed at the previous meeting be read and corrected or approved, as the case may be."

It was also resolved that no resolution shall be voted on until it has been fully reduced to writing, read and approved by the propounder and his seconder.

REGULAR MEETING, December 19, 1912.—Present: President Hess, Directors Halstead, Kerrick, Develin, Gilpin, Vogleson, Haldeman, Swaab, Worley, Yarnall, the Secretary and the Treasurer.

The minutes of the meeting of November 14th and the motions and resolutions of the meeting of November 14th were read and approved.

The Treasurer's report was read and approved.

The Secretary's report was read. A resolution, relative to Mr. Plack's resignation was passed, as follows:

"*Resolved*, that it is the sense of the Board of Directors of the Engineers' Club of Philadelphia that it would be extremely unfortunate for the Club to lose the services and association of Mr. W. L. Plack, who for many years has served the Club earnestly and efficiently. We therefore ask that Mr. Plack seriously reconsider the matter of his resignation."

Mr. E. S. Morrell's resignation was accepted as of December 31st, 1912.

The reports of the Finance, Library, House, Advertising, Public Relations and By-Laws Committees were read and approved.

The report of the Membership Committee was read and approved, and the following were elected to membership: Active—J. Willard Gamble, Silas G. Griffith, Paul C. Haldeman, Allen S. Hurlburt, John J. Young, Jr.; Junior—Edward H. Blum, Charles C. Campbell, Alexander P. Gest, Jr., T. Otto Mayer, David M. Niver. John Horridge and John A. Remon were transferred from Junior to Active membership.

The Business Manager's report was read and approved.

It was decided that in the matter of a legal quorum of the Board, the election of officers to the Club, the letter ballot and the legality of the By-Laws, be referred to a Committee of three, and the President appointed the following to constitute this Committee: J. A. Vogleson, Chairman, S. M. Swaab and W. P. Taylor. The Committee was then instructed to gather the information and data relative to the above subject, and present the same to the Board at their next meeting, in order that they might decide the matter of referring the same to counsel for report.

The question of allowing the Aero Club of Pennsylvania to make their headquarters at the Engineers' Club of Philadelphia was discussed, and it was re-

solved that the Board authorize the renting of desk space or a room to the Aero Club, to be used by only the Secretary and President of the Aero Club, and the Board referred to the House Committee for its recommendations to the Board the matter of rental to be charged.

The Secretary was instructed to inform the Board of Directors of the Aero Club of Pennsylvania, at their meeting to be held December 20th, at 3.30 P. M., as to the action taken by the Board in the matter.

Photo by Evans Studios.

HENRY HESS

35TH PRESIDENT OF THE ENGINEERS' CLUB OF PHILADELPHIA

Editors of other technical journals are invited to reprint articles from this journal, provided due credit be given the PROCEEDINGS

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE—The Club as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XXX APRIL, 1913. No. 2

ANNUAL ADDRESS

BY THE RETIRING PRESIDENT

HENRY HESS

February 1, 1913

This being the last meeting with the present Board, the new officers coming in with the next meeting, a motion to adopt or otherwise discuss the Annual Report is in order. You have had that report mailed to you and it is before you now. I would call your attention to just a few things to be found in the annual report which may be of particular interest to you.

We had, in 1911, a total membership of 587 members; that increased by 12 members, net, in the course of the year, so that at the end of 1912 we had 599 members. For the year 1912, taking into account the people who have applied for membership, and who have been recommended for membership, the total membership will be raised to 611, which is not as much gain as we have had in some years, but is rather an average gain—about 24 members gained for the year.

What your Club needs for its continued welfare, and to put it on its way to getting along just a little bit easier, is a few more members. During the course of the year occasion has been taken several times to call attention to the need for additional membership. It is the

one imperative thing that the Club needs. Your Club is not getting along comfortably; your Treasurer finds it quite a hard job to make ends meet, and in order that the Club might live easily, the Treasurer and other officers have more than once applied their own personal funds to the tiding over of temporary difficulties, and also used their personal credit in endorsing your Club's paper. A matter of fifty new members would change the whole situation, and you will be absolutely in a position where your credit will be that of a good financial institution, able to promptly take care of its bills and to discount them. If every member of the Club will constitute himself a Committee of One, to get in a new member—or if only ten per cent. of our membership would do that—you will have the Club on Easy Street in every way possible.

The Suspense Account for the year amounted to $695. It has been the fashion heretofore to carry in your Suspense Account dues from people who claimed having resigned. Yet, the resignation was in a form not recognizable under the By-Laws. While they were able to make their resignation actually effective by refusing to make further payments, the Management took the ground that they still owed their dues. The Suspense Account shows for the year 1912, as compared with a previous year, a less favorable statement of your finances; it is actually a more favorable one, because these technical defalcations have been entirely omitted, so that every dollar shown is a dollar of assets. Accounts receivable are actual accounts receivable, worth their full face value. In reading the old statements, the account ought to be liberally discounted to show the real standing.

During the past year, the Club has really taken on the functions of a Club Hotel. You have added to the facilities a considerable number of bedrooms and have also increased the ability of your restaurant to take care of the needs of this increased patronage; this has been so much appreciated that your rooming facilities have been taken advantage of in excess of eighty per cent. average. There have been times when people had to be sent to the Hotel Stenton, where arrangements were made for them to be taken care of at the same rates as here at the Club.

And now, leaving the annual report, I will ask your indulgence for a few minutes, during which I will attempt to analyze some of the Club's affairs by the use of diagrams. Considerable work on the

part of your Business Manager was required to get some of this together, so that some of it has come to me only as late as this morning, and I must therefore ask your indulgence for simply talking with some diagrams to refer to and a few brief notes that I have not had time to rewrite.

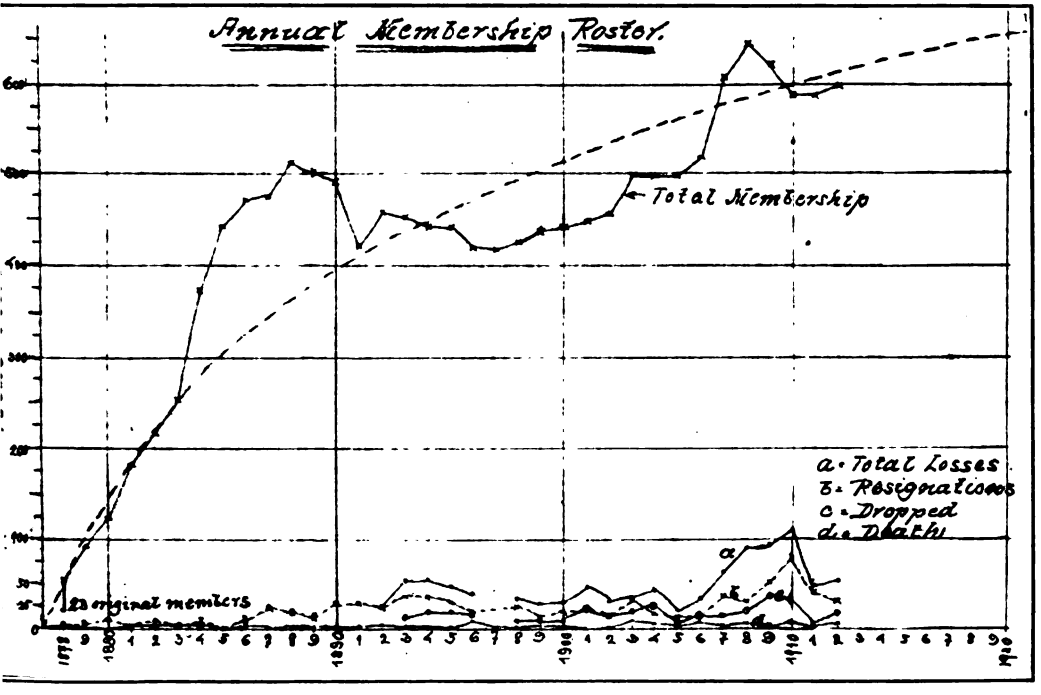


FIG. 1. INDIVIDUAL MEMBERSHIP ROSTER.

Chicago and New York are always ready to talk about Philadelphia being slow, but here is evidence that Philadelphia is not slow; Messrs. Williams, Browne and Earle have turned these slides out for me since three o'clock this afternoon, Saturday afternoon at that.

You will notice this (Fig. 1) gives a total of the membership from the beginning of the Club in 1878, at which time you started with twenty-three members, increased to 58 by the end of the year. I have drawn verticals for each 10-year period. There was a satisfactory growth up to 1883, when there set in a very sharp acceleration. Older members have told me that this was due to individual propa-

ganda and the entry in permanent headquarters on Girard Street. Before that, I believe, the members met wherever they chanced to get convenient places. In 1888, you got up to 512 members. There was then apparently a drop to the low water mark of 1890-91.

I have heard that about that time some friction developed such as comes at some time in the history of most institutions. The dotted line may be taken as a fair average of the Club's growth. Then you went along with small variations, evidently needed time to recover. About 1902 to 1903, recovery came and then grew rapidly and went beyond the average by 1908 at the time you entered into the enterprise of your own Club House. There was also a raise of dues from $15 to $25; I th'nk that was in 1908, and then a further raise of dues the next year from $25 to $35, which evidently caused a number of members to drop out. However, the reaction seems but a natural one, as it did not affect the average (dotted line) growth line. This average line indicates that your Club is progressing fairly along the lines of original promise.

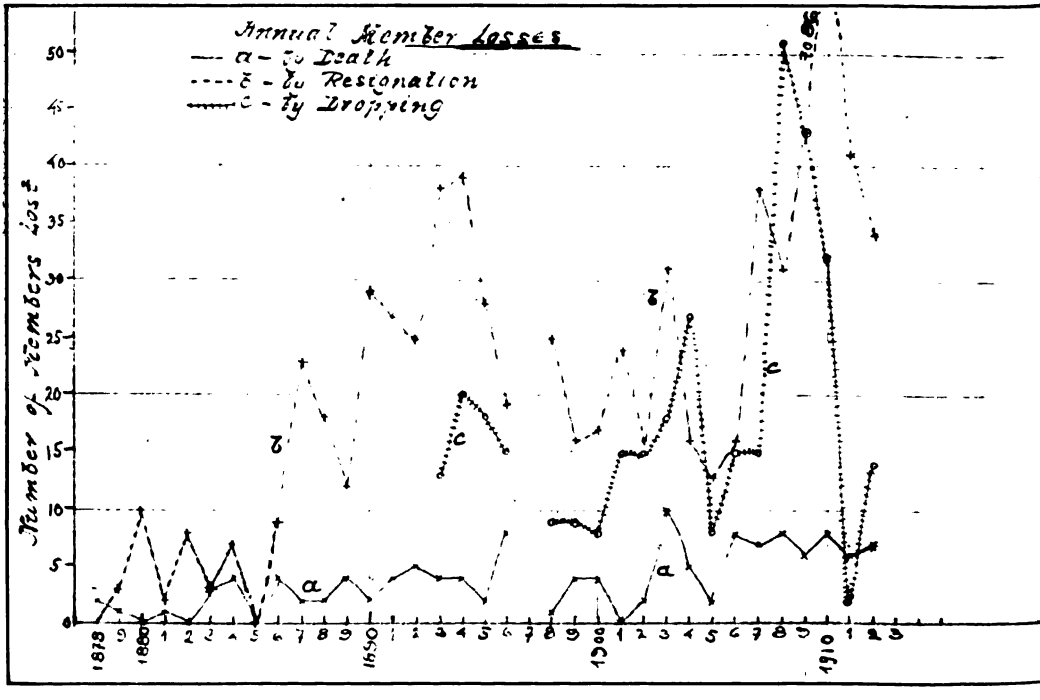


FIG. 2. ANNUAL MEMBER LOSSES

The lowest line shows the toll levied by the indefatigable reaper. A distressing loss is shown by "B" line, which indicates resignations, the maximum being reached in 1895. I cannot find anything which would indicate a reason for that. Your maximum yearly losses by resignation was 86 members, throwing the line off the diagram; that was in 1910, which was the year pending the maximum increase in dues to $35. In the earlier years there were carried as members a good many people who were really not members. They received the Transactions, but did not pay their dues, and were not dropped as they should have been under the By-Laws. The first record of anyone being dropped was in 1893 ("C" line). That reached a maximum in 1908 of about 51 members dropped from the rolls for non-payment of dues and similar reasons.

Your incoming Board will undoubtedly welcome any suggestions that can be made by any Club member as to what he conceives to be the reasons for the erratic record of resignations. There must be underlying causes, and if these causes could be removed, that would be very much to the benefit of your Club.

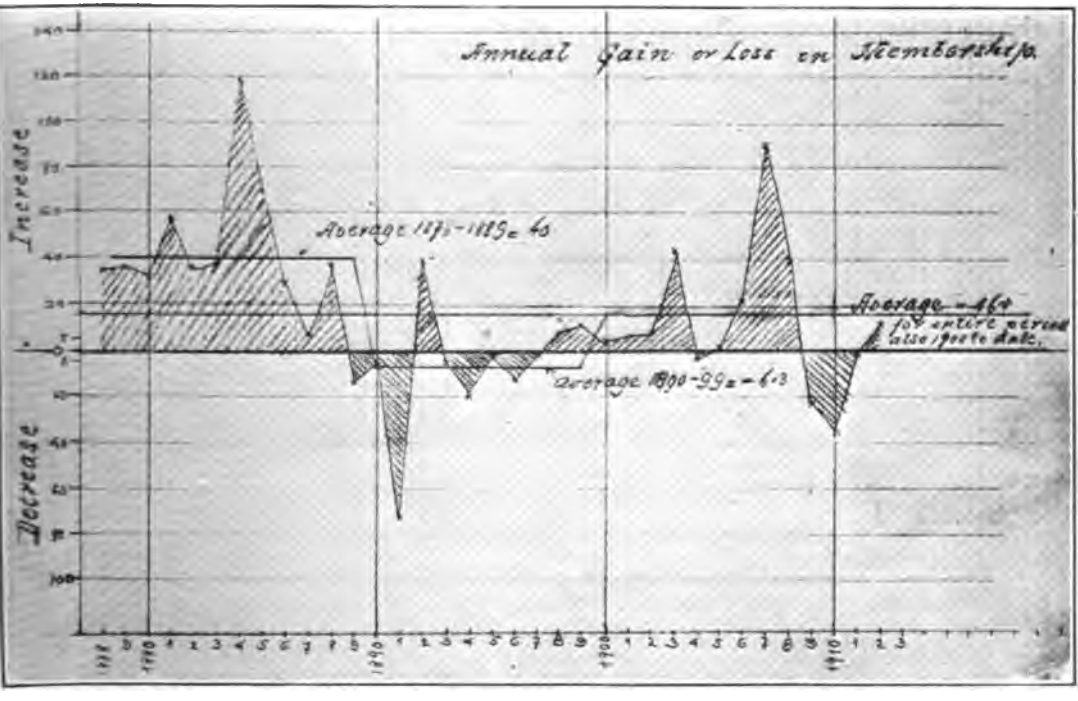


FIG. 3. ANNUAL GAIN OR LOSS IN MEMBERSHIP

All above the zero line is gain in membership, and everything below is loss. The first year showed an increase of 35 members, and one year—1884—of 119 members. You have never gained as many as that in any one year since. You went on gaining up to 1898, which records the first actual decrease of 18 members. Then you kept on losing members for about three years, and after that turned the tide with the next largest gain, in 1907. You see that that coincides about with the largest total loss in membership. The raise to $35 in the dues again resulted in a loss. If you take your average increase of membership per year to date you will find it to be 16. Peculiarly, the average increase for this last ten year period is identical with this average for the whole period of your existence.

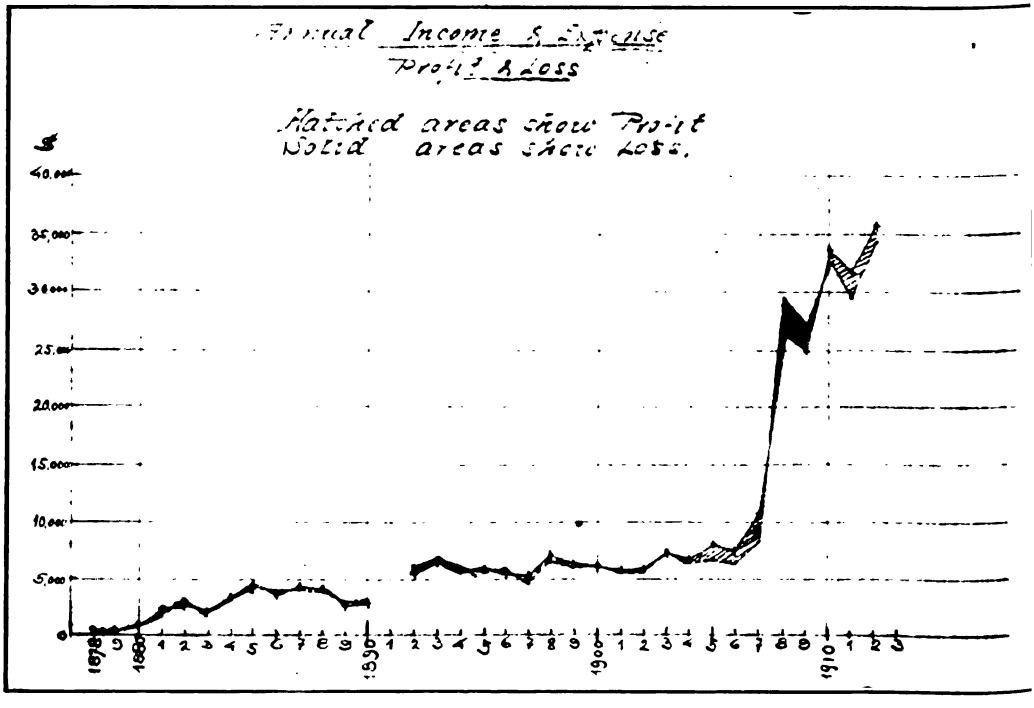


FIG. 4. ANNUAL INCOME AND EXPENSE, AND PROFIT AND LOSS

In a general way, when the expense has gone higher than the income a loss in membership is shown. In such, the area enclosed by he two lines is solidly black. You run along sometimes with a small

deficit, sometimes with a small surplus, resulting in a fairly substantial surplus in 1905 and the two following years in 1908 and 1909 you have a deficit, changed to a surplus in 1910, and since maintained the line at the right side of the ledger. Relatively, this surplus is far better than the figures show being safer and more conservative, since everything which ought not to be there has been taken out, under a scrutiny far more rigid as to your assets and bills receivable.

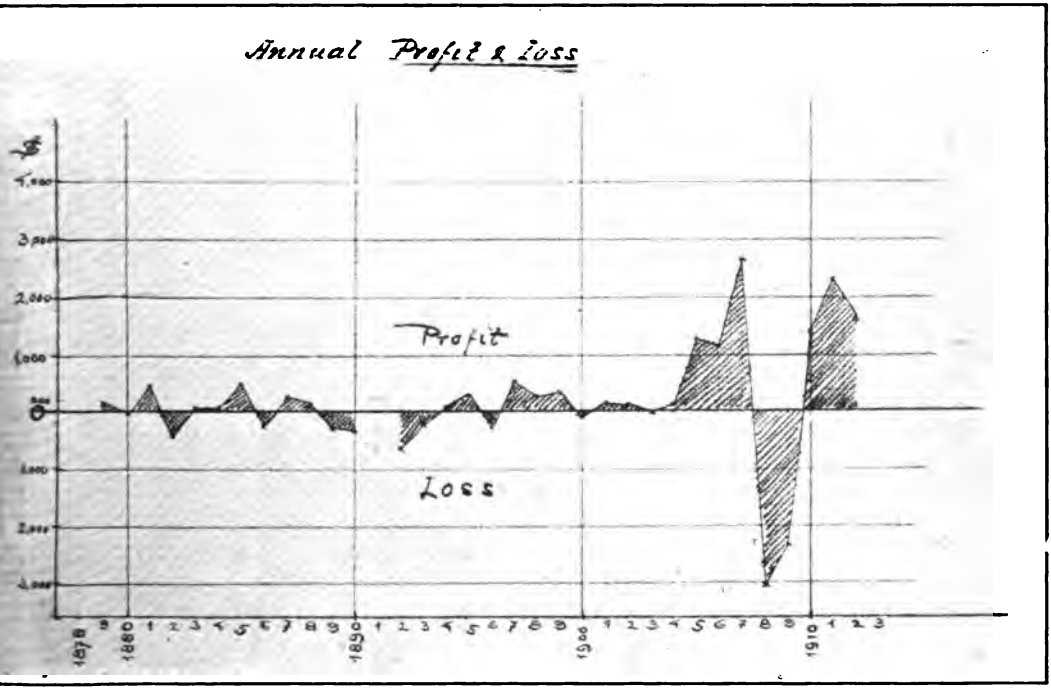


FIG. 5. ANNUAL PROFIT AND LOSS.

Here I have taken again the data shown on the last sheet, but in order to make it clearer, I have referred the profit and loss as plus and minus on either side of a zero line. This shows your surplus for the different years. The decrease in 1908 was larger than any decrease which you had before.

You can say, in a general way, that your surpluses are not cash surpluses or money in the bank. It is your net worth, but does not mean that you owed that much money at that time; rather that your

book liabilities were larger than your book assets; your book liabilities include matters which are not cash just as your book assets do.

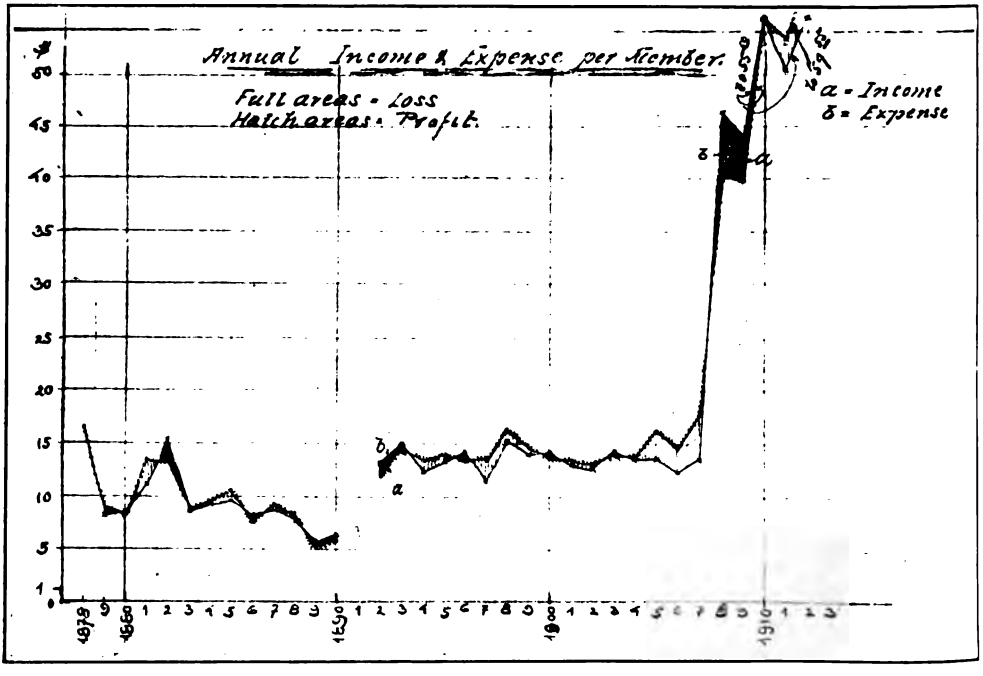


FIG. 6. ANNUAL INCOME AND EXPENSE PER MEMBER.

You have here again your annual income and your expense, but from a different view-point. Whenever your book income exceeds your expense, that is shown by a cross-hatched area and when there is a deficit that is shown by a solid black area.

Fig. 7. This diagram is somewhat more instructive as it shows the profit and loss with reference to the individual members. This is the annual profit and loss per member. You will see that in your first year of business in 1879, you had a fair profit per member of one dollar. In the next year that decreased to 35 cents, then rose to $2.75 per member, and then it dropped to $2.00 on the wrong side of the ledger per member. In your early days you see you had quite large profits and large deficits per member. Here in 1908, there was a deficit per member of about $6.00, changing to zero in 1910, when you broke just even, and the next year you went to $3.00 and in

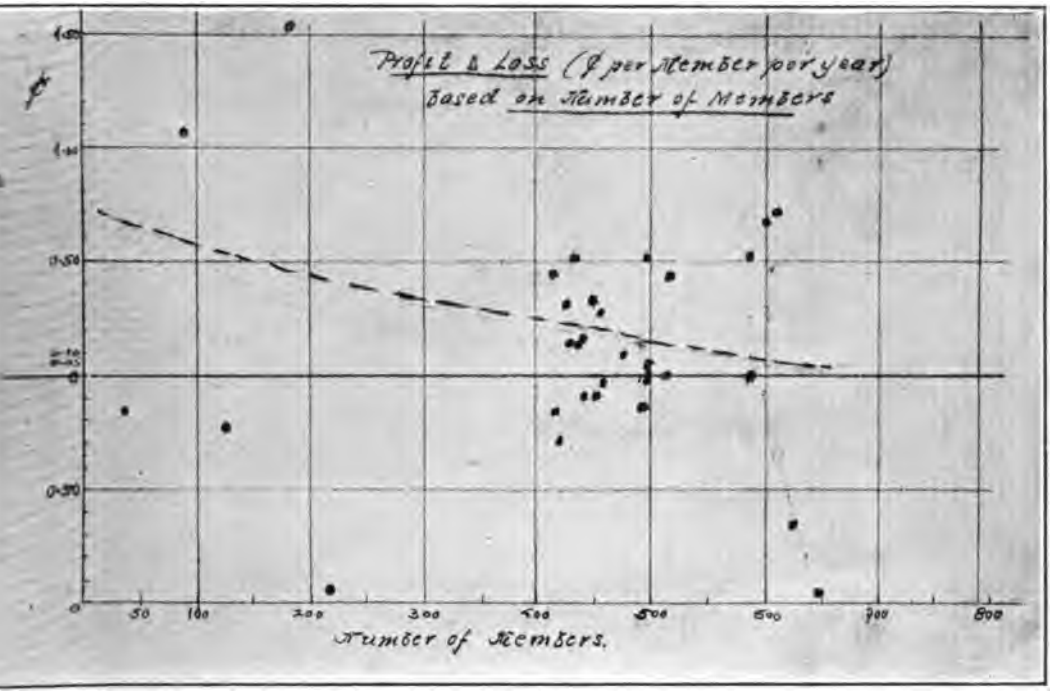


FIG. 7.

1912 to $4.00 profit. That 1912 showing of $4 surplus represents real values with all doubtful accounts eliminated and is a fairly satisfactory showing.

Fig. 8. Profit and Loss per Member per Year.

This is an attempt at studying the relationship of the cost per member with the total number of members. When I am making castings, I know they will cost me more per pound or per ton for a small total output than they will if I am turning out castings in large quantity.

The greatest profit of $1.55 per member, per year, attended a total membership of 180, but a slight increase to 218 members diminished this to a loss of $ .90. The record shows a decrease of variation as the membership increases. The dotted line (which shows the average) has not been calculated, but traced in by the eye. It shows a trend to a decrease in profit per member per year, as we increase in

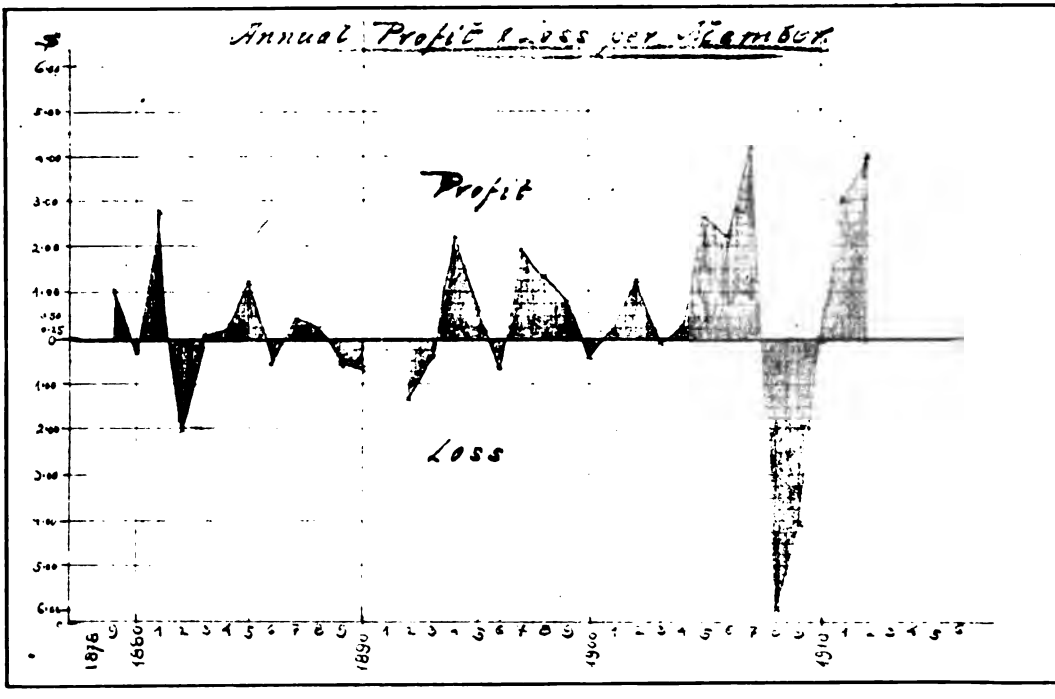


FIG.8. PROFIT AND LOSS PER MEMBER PER YEAR

members. That is no doubt because an increase in numbers, and with that in income, brought in its train an increase in our wants. For instance, we went out of a simple place on Chestnut Street where the profit per member was very much higher than it was when we were at Girard Street, and then to this house. Each member gets many things not had before, naturally with a decreased profit per member. I think it is safe to say we are not likely to further increase the expense per member in this house. The cost per member now so far as our publications are concerned is reasonably stationary; the restaurant losses, now rather large, are lessening with increasing patronage; we may even look for a tendency in this line to reverse to an ascent. It is a healthy sign that it has maintained its average on the profit side. It should not be more than slightly above zero, as it is not the purpose of the Club to make money. The profit

per member per year should be as low as possible, always with an eye directed toward a safe total amount from the total membership.

Let us hope that the decrease in our book surplus has its compensations in things that cannot be booked. We cannot put them on the diagram. I hope that every member will feel that he is getting his full share of the benefits, and will make every other member feel that he is getting his, and if he does that we are working towards an increased surplus, tangible and intangible. An increasing membership will increase the possibility of giving to each member increasing value in every direction.

There are new features already in growth that make for actual loss; I am now talking of the losses that the ledger will show. At the old quarters expenses were limited to rent, to the business meetings, the technical meetings and the transactions. You now have a Club with Hotel and House conveniences. You fill your rooms at a fair rental, but moderate as compared with a hotel charge for similar comforts; the few cases of occasional discomforts are fast being eliminated with increasing expenditure; your rooms are a source of profit, small, but actual profit. Your restaurant, as are most Club restaurants, is run at a loss. Some features show a profit, such as the sale of cigars and liquors. On the sentimental side, there is ample justification for that loss. Your Club is to a certain extent your home, you do not count as loss the cost of that. The restaurant is profitable in another way, it brings guests—a great many guests—it also has some influence in increasing our membership. Turn to another phase. You now have a house which is a desirable meeting place for all sorts of technical organizations, and so are the nearer to the ideal of your organization. You meet here in technical sessions probably more often than any other engineering o ganization in the country. There are few, I believe, that meet fortnightly, many do not even meet monthly. Quite a number of organizations have applied for the privilege of meeting here, and some of them have asked for permission to make this house their headquarters. Some are now so located, that is, their secretaries have desk room and pay desk rental. Some of them have asked for the privileges of the house, which, however, could not be granted.

There are four now who have made arrangements, and three more have asked for it. They pay rental for the auditorium when they use it, and they pay rental for their secretaries' desks.

PAPER No. 1119

THE IMPORTANCE OF METEOROLOGICAL DATA IN ENGINEERING

BY GEORGE S. BLISS

Director of Pennsylvania Climatological Service

Read September 21, 1912

The increasing use of meteorological data by the great industrial interests of the country during the last five or six years has been remarkable. The conduct of business with due regard to the effects of weather changes and of general climatological conditions is rapidly coming to be recognized as not only convenient, but decidedly profitable. This is true to a greater or less extent in practically all lines of industrial activity, and much of the permanent benefits accrue through its application to certain classes of engineering work.

Our progress, during the last decade, in the development of hydroelectric power, in irrigation and drainage work, in the installation of adequate and efficient water supply systems for the larger cities, and in the improvement of our waterways, has been phenomenal, and it is apparent that we are entering upon an age of growth and development along all these lines such as the world has never known. No engineering scheme, covering any phase of this work, can be intelligently formulated unless full consideration is given to the meteorological conditions inherent in the locality.

The agricultural engineer, a combination of engineer and scientific agriculturist, is recently coming into prominence in this country. The successful conduct of his work demands a continuous use of meteorological records as well as intelligent application of many of the known laws of atmospheric physics. Thus in addition to being an engineer and a scientific agriculturist, he must be something of a meteorologist. In the mountainous portions of the country, and especially in the large fruit growing districts, the matter of air drainage has become equally as important as that of water drainage.

The city engineer should take into account not only the average precipitation for his locality, but also the excessive rate of rainfall on unusual occasions, and should plan his drainage accordingly. The overflowing of water from the streets into basements and the bursting of sewers during heavy rains have frequently emphasized the need for more careful computations in these matters.

It used to be customary, in the construction of railroads and highways, to install such bridges and culverts as the judgment of the engineer dictated, and then later to build larger and more substantially at those points where washouts proved the inadequacy of the first structures. Much of this inconvenience and expense is now being avoided by an intelligent consideration of rainfall records in connection with the topography of the country.

The use of meteorological records by the engineering profession became so great that in 1908 the Chief of the U. S. Weather Bureau decided to compile and publish all data by drainage areas instead of by state boundaries as had formerly been done. Beginning with July of that year, he divided the country into twelve districts, comprising the twelve principal drainage systems, and appointed a district editor in each to compile and summarize the records for publication. As now issued, the data for each drainage area comprises a separate of the "National Monthly Weather Review." These separates may be obtained by interested persons upon request and without cost, while a subscription price is charged for the complete "Review."

The launching of a great reclamation project requires first of all a careful estimate of the agricultural possibilities of the region in question, in order to determine what would be a reasonable expenditure in carrying out the work. This estimate must include several factors, chief of which pertains to the climatological features not only of the district which it is proposed to reclaim, but of the drainage basin which is to furnish the water supply. It is especially important to determine with reasonable accuracy the run off from this drainage basin during the driest and wettest years. The agricultural value of the reclaimed area will depend not merely upon its topography and the quality of its soil, but also upon the usual conditions of temperature, wind and sunshine, the rainfall in this case being of secondary importance. The average length of the growing season, or in other words the average time between the last damaging frost of spring and the first of autumn, must be considered at all events.

Irrigation, drainage, and the development of hydro-electric power are often intimately associated by combining facilities for sub-surface irrigation with those of tile drainage, and by installing power plants at the retaining dams of great irrigation systems. Tile drainage has been found to be almost as beneficial in dry seasons as in wet ones, and more land has been reclaimed by drainage than by irrigation. It may also be mentioned that in some places hydro-electric power is being used to pump or elevate water for irrigating purposes to points that would otherwise be inaccessible.

In addition to the large field, as outlined, in which the meteorological data are of prime importance, it may be suggested that the rainfall records offer an opportunity for the engineer to greatly enlarge his field of activities. A careful study of the rainfall records for the United States reveals the fact that there are few, if any, agricultural districts in which the rains are so dependable as to make irrigation unnecessary or unprofitable. Almost invariably there occurs a period during each growing season when the deficiency of moisture is such as to check the growth of vegetation. Irrigation at such times would greatly increase the production and might double or triple the yield, or even produce a good crop where practically all would otherwise have been lost. With the demands for produce rapidly outstripping the supply, more intensive methods of agriculture are becoming imperative in this country, and facilities for irrigation form the chief problem in this connection.

Many valleys offer opportunities to lead water from streams at the upper reaches and conduct it in flumes along the hillsides above the land to be irrigated. In other places it may be necessary to elevate the water by hydraulic power, and in still others wind power may be utilized for large pumping operations. All of these problems are for the engineer and in fostering and developing them he can make extensive use of the meteorological data that can be supplied by the U. S. Weather Bureau.

Data for a definite locality may often be unobtainable, but in this country they can usually be interpolated with sufficient accuracy from nearby points where records have been kept. An instance of how this can be done may be cited in the Los Angeles water project, which ranks among the greatest engineering feats that have been accomplished by municipalities. When it was proposed to bring water to Los Angeles from the Owens Valley, a distance of 200 miles

over mountains and deserts, it became necessary to ascertain the water resources of the valley. Old precipitation records were not available from a sufficient number of points to establish the average rainfall as well as the extremes for the valley, and to determine its relation to the run off.

Rain gauges were therefore located at numerous points and their catchment for several months was pro rated with that of the permanent gauges. The application of these ratios to the older records formed a satisfactory solution of the problem. The flow of the small mountain streams was also measured and it was found that seepage and evaporation are so great that only fifteen per cent. of the precipitation finally reaches the Owens River.

The United States Weather Bureau maintains something over 200 stations at which complete meteorological records are kept. In addition to these there are more than 5,000 co-operative stations equipped with standard thermometers and rain gauges. Consequently, there are few localities more than 75 to 100 miles from a regular Weather Bureau station, while temperature and precipitation records are available at one or more places in nearly every county.

At a majority of the stations the records cover periods of ten years or more, and in nearly every state there are several points at which they have been kept for 30 years or upwards. Usually a ten-year mean will vary less than ten per cent. from a thirty-year mean, and ten years of complete data may be depended upon to include the extremes except those rare occurrences which become matters of historic comment.

Most of the records for the whole country are on file at all the larger Weather Bureau stations, but that fact is not so generally known as it should be. Nearly every engineer who has visited the Philadelphia office has commented about the large amount of meteorological statistics available.

At present we are recording precipitation measurements at about 100 places in Pennsylvania, mostly in small towns along the railroads and in the valleys. It is my belief that the number of stations should be nearly doubled, the increase being distributed wherever possible over the higher ridges and the headwaters of the principal streams. Precipitation records are to become such an important factor in our industrial development of the near future that there is little danger of accumulating excessive or unnecessary data of this character.

The Weather Bureau data comprise not only the ordinary records of temperature, precipitation, wind, and sunshine, but also include gauge records of all the principal streams. These river gauge records are indispensable in calculating the run off for a given drainage area, or for determining its relation to the precipitation. During the last few years the Bureau has maintained a large number of special snowfall stations in mountain districts of the far West, and thus reliable information is furnished regarding the reserve water supply for many power plants and irrigation operations.

In closing I wish to express my belief that in the future the hydroelectric and the agricultural engineers are to become the leaders of the profession, the opportunities of the agricultural engineer being practically unlimited. Their efficiency will depend, in no small measure, upon their ability to make intelligent use of meteorological data in their computations.

DISCUSSION

MR. JOHN C. TRAUTWINE, JR.—I need hardly remark that Mr. Bliss is entirely mistaken in saying that one of the chief merits of his paper was its brevity. It might well have been much longer.

The activities of the Weather Bureau admirably illustrate the fact that not only can the Government do some things better than the individual or a private corporation, but it does things which no individual, firm or corporation would undertake, because there is "no money in them."

If I understand Mr. Bliss correctly, the complete records for each district are sold on subscription (and I venture to say that the fee is very moderate) while the separates can be had for the asking.

I know of no one who is better qualified to discuss this question than our veteran fellow-member, Mr. Codman, to whom we are indebted for many years of hard, painstaking and intelligent work in charge of the city's gauging stations, and for the city's success in wheedling, out of the City Councils, the paltry sums required to keep these stations going.

MR. CODMAN.—For the past twenty-nine years, the Bureau of Water, Department of Public Works, has maintained a series of observations on rainfall and stream flow, and have secured valuable data on a number of streams in this vicinity, including the Schuylkill River.

A discussion of the whole subject of rainfall and stream flow in connection with the value of meteorological observations to the engineer would consume much more time than is usually allowed in discussing the main topic of the paper. I will, therefore, confine my remarks to the collection of the rainfall data and its value in computing its sequence in the amount found flowing off in the natural water courses and drainage from the surface of the ground.

In computing the rainfall from the surface of the ground, dependence upon the flow-off computation must be to a large extent based upon the accuracy of the scientific observation.

As these observations are, for the most part, made by voluntary observers, it often occurs that a break will be found in the data of several months or more at a time, and a long continued series of observations without a break is very rare, and a complete record is extremely valuable to the engineer in making up the computations. The Bureau has paid the observers employed by it a small monthly salary, and by this means has succeeded in getting a very valuable record.

In recording data of this kind, it is important for accuracy to observe a number of points, first, that the rain gauge shall be so placed that it is not interfered with by surrounding objects, causing it to collect more or less than the normal quantity by air currents or eddies of air.

Size of Gauge—I have found from experiments that the size of the rain gauge is not essential, as a 2-inch gauge will record, approximately, the same amount as a 20-inch gauge, if care is taken in the small gauge by using a proper displacement measuring stick; and in the larger one to avoid placing it where the action of the wind would blow the rain drops out of the receiver.

It has been asserted that rain gauges near the ground collect more than gauges that are raised high above the ground, but not so high as to be above the foregoing cloud. This, so far as the experiments made by it are concerned, is not correct, gauges at an elevation of 200 feet or more showing the same as those 4 feet or 5 feet from the ground.

The observations on rainfall in the Bureau serve to show a considerable difference in the amount recorded by gauges forty or fifty miles from Philadelphia at elevations 400 to 600 feet above that of Philadelphia. In Philadelphia, the average rainfall for twenty-nine years is about 41 inches; at Seisholtzville elevation 870 feet (U. S. datum), the rainfall for the same period of time is 48.6 inches; and at Doylestown, elevation 405 feet (U. S. datum), the average rainfall for the same period is 47.9 inches.

Another assertion that I have often heard made is that there are certain periods or cycles in which observations will repeat. This, I think, is also an error, as there seems to be indefinite periods in which there is more or less than the normal average. The distribution of the rainfall throughout the year is quite available and it is in connection with the meteorological observations that this available distribution must be carefully considered in making stream flow computations.

The average rainfall may for several years not be much below or above the normal, as the rainfall in the streams is most decidedly affected by the meteorological and available conditions, through the year. A series of errors which often occurs is in the measuring of the snow fall and reducing it to water. Various methods have been employed for doing this. The 8-inch gauges used by the Bureau give very good results, as they are so made that the measuring tube can be detached, and the snow falls into the outside reservoir and is melted into water by the observer.

The snow fall in this climate often forms a large part of the rainfall. That

which falls upon the ground during December, January and part of February remains on the ground and shows in the increased stream flow during March, and if not carried entirely away by warm rains, produces freshets, which will gradually pass into the ground storage, affecting the volume of stream flow during the summer months.

The meteorological conditions of temperature, cloud area and humidity of the atmosphere play a very important part in the run off of the rainfall from the surface of the grouud much more than many persons suppose.

I am also of the opinion, from my own observation in connection with data obtained by former observers, in some cases from long series of observations, that the removal of the forests has not made any effect upon the total precipitation, the average yearly rainfall remaining about the same from year to year.

You must remember that the stream flow depends entirely upon the rainfall. All the rivers and streams are fed by springs, and the supply of the springs is the rainfall. That constitutes what is called the ground storage. With the exception of freshets, the greater part of the water flowing in rivers is taken from the ground storage. If there is a deficiency of rainfall in the spring, fall and winter months, the ground storage will not fill up, and during the months of greatest evaporation, say, starting with May to October, if there is an excess in the amount of rainfall, the ground storage will decrease, followed by a corresponding decrease in stream flow.

DR. HENRY LEFFMANN—I wish to express my appreciation of the paper, and to speak of one point that has especially attracted my attention and has gratified me. I have for very many years been a nationalist, that is, in favor of abolishing state laws. I note that the reader of the paper has said that in the study and utilization of certain data, the United States authorities have made their maps on drainage areas, ignoring state boundaries altogether. I hope the good work will go on along this line. It is, I think, evident that necessary sanitary reforms, such as conservation and purification of water supply and mosquito extermination, can be effected only by nationalization. To follow Mr. Codman's later remarks on intermittent streams, I think we would be in error to assume that the underground supply is only from the immediate subsoil. I have made analyses of the waters of this region, and it is found that the so-called "deep waters" are very different from the true "ground waters" which are derived from the rain water of the district. Deep waters are usually rich in mineral matter, especially calcium, magnesium and iron compounds and sodium chloride, and lacking in nitrates, which are almost always in subsoil water. It seems to me that it is not at all impossible for these deep waters to supply some of the streams through crevices reaching to considerable depths.

It is known that the artesian wells at Atlantic City, some of which are several hundred feet deep, are slightly affected by the tide, the water level rising a foot or so at high tide. I think that this is due to the pressure of the tidal wave upon the water-bearing strata.

MR. H. H. QUIMBY.—There are two classes of meterological data that have not received much attention this evening, and which I think are of importance

to the Engineer. One is the matter of wind pressure, and the other is the weight of snowfall.

Many of our structures are required to resist wind pressure, and all of our structures have to carry the weight of snow.

I had occasion to inquire into the question of the weight of snow that our roofs are liable to be subjected to, and I wrote to the Weather Bureau in this City for information. I have to acknowledge my gratitude to Mr. Bliss for his painstaking reply to my inquiry. He gave me very complete data, not only the record of the amount of snowfall, but the equivalent amount of water that it represents.

It may be of interest for me to say that his records went back forty years, and the heaviest accumulation of snow (not the heaviest single snow storm) was 11 pounds per square foot.

The observation of wind pressure, however, seems to me to be very unsatisfactory as made by the United States Observatories. So far as I know, they attempt to record only the velocity of the wind, and then some empirical rule must be used to convert it into pressure. I believe the measurement of the velocity of the wind is usually done by an instrument—an anemometer—whose registry is multiplied by an arbitrary factor as a constant. It seems to me that it would be much easier to measure the actual pressure that the wind is exerting on a given surface than to measure the velocity of the wind, and I do not know why they do not use instruments for measuring the pressure. That is what we want rather than the velocity. If Mr. Bliss can give us any light on that, I think it will help us somewhat with the problems that come up from time to time.

MR. BLISS.—There have been in use at various times in the Weather Bureau, instruments to register the pressure of the wind, and they have not been really satisfactory. The best thing that is out at the present time is an instrument that is liable to be used at the larger stations; that is, the Dines Wind Pressure instrument. It is constructed in such a way that there is a sort of funnel turned towards the wind at all times, and the wind blows down the pipe on to a surface of mercury, and the pressure is mechanically recorded on a sheet of paper which revolves on a cylinder.

The gentleman is right in stating that our wind data is of no practical value to engineers, and therefore I steered clear of it, as I thought, tonight. We have had a great many inquiries, and we have a great many tables calculated from anemometer readings and formulæ, calculating the wind pressures from that. In the Robinson cup anemometer, there is a considerable amount of friction in the instrument in a long collar bearing at the upper end of the spindle. I do not know why the U. S. Weather Bureau has used such an instrument for so many years. I remember when I was up at the Washington office some little time ago, Dr. Marvin told me they were getting out an instrument with ball bearings, that will be very useful. The Robinson instrument revolves on a steel gear on a hard surface, so as to reduce the friction as much as possible, and at the top of the spindle it passes through a collar, and there is an actual collar bearing about an inch long. You can therefore understand that the friction there is considerable in light wind velocities, and the faster the cups go, the less that friction

becomes proportionally. They have tested out the anemometer friction at different velocities and prepared tables for it, but the wind data is very unsatisfactory even with that figured out, for the reason that the anemometer really figures nothing until you get to the end of a mile of wind movement. It is not the velocity of the wind for a mile of wind movement that interests you, not the extreme velocity for a five-minute period—I understand that—but it is the wind pressure during the gusts. The Dines pressure instrument shows—(where it has been installed in connection with the anemometers)—that the velocity of the wind during a storm is something more than twice the velocity during the gusts as compared to the steady average rate.

You now understand that with the feeble position we are in for giving data on the wind, why I tried to steer clear of it, but I did not get out of it altogether.

MR. JOHN C. TRAUTWINE, JR.—The instrument just described recalls Gauthey's "pressure-plate," which was a metal plate, suspended by one of its edges, about which it was left free to swing. The plate was immersed in the stream, with its face normal to the current, and the velocity was inferred from the weight required to keep the plate vertical in opposition to the force of the current.

Experiments upon wind-pressure, to be of much benefit to the engineer, would have to be made with surfaces of a wide range, as to size and shape, and as to character of exposure. A very important factor, affecting the pressure at a given velocity, is of course the inclination of the surface to the wind direction. One of our engineering periodicals ("Engineering News," if I remember rightly) recently published an account of experiments on a fairly practical scale, in this direction.

I heartily sympathize with Dr. Leffman's desire for the obliteration of state lines, or at least for their rationalization. Such lines obstruct many useful activities, notably that of water supply, by interposing artificial difficulties in the way of interstate projects. Boston and its neighboring towns have eliminated the unseemly scramble between such communities for water supply by organizing their Metropolitan Water and Sewerage Board; and I look for the time when we shall have our water supplies distributed by state, if not by national, instead of by municipal, authority.

MR. BLISS.—I have never heard of such an instrument being used. Until the Dines instrument had been tested in the Weather Bureau, the method was to expose a plane surface to the wind and measure the pressure by the compression of a spring, by the movement of a balance or weight, which would be something of a pendulum system; but the only satisfactory system has been this Dines instrument, and I am in hopes we will have one in Philadelphia before very long, because I realize that it furnishes the only reliable data we can get for structural work.

On our interstate railway time-tables, the names of the states traversed are commonly omitted. This indicates how little importance is attached to state-lines by those state-agents, the railway corporations, whose chief interest, in such matters, probably centers about the comparative purchasabilities of the several state legislatures.

MR. E. M. NICHOLS.—I would like to ask Mr. Bliss what is involved in this Dines instrument. I understand it is the official recording instrument. What tests have been made to prove its accuracy?

MR. BLISS.—That has been computed, of course, by the inventor and maker of the instrument. I suppose they worked it out by taking pressures by some other means, and the accuracy of the pressure was determined on a mercury surface, moving the mercury in a "U" tube; that pressure is more accurate than you can get by the compression of a spring. The action is not great, but it is magnified something as it would be in an aneroid barometer, and the recording pen is comparatively accurate. The record sheet is gauged for different velocities, being ruled with horizontal, parallel lines. The pen plays up and down and records the extreme pressure much as the aneroid indicator on the dial would respond to the atmospheric pressure.

MR. NICHOLS.—I suppose that is no mechanical connection between the wind pressure and the gauge? That is, the wind pressure acts directly upon the mercury?

MR. BLISS.—Directly upon the mercury.

MR. CHEYNEY.—I do not know that I can add anything to what has been said. I regret to state that we have not been able to collect data of our stream flows continuously, and on this account our records of these flows are not of much value. Our observation of stream flow has been confined to the driest periods only of the past few years. We have a number of rain gauges located at different points in the state, and the records obtained at these stations will in time be valuable as an adjunct to the government and other records which are being kept.

I would like to ask Mr. Bliss whether he has knowledge of any records of daily evaporation, or knowledge of any records of evaporation at different times of the day. This is a matter which may be of considerable importance in getting correct records of stream flows if observations are not taken continuously. My attention was called to this a few years ago by an engineer employed by the Cambria Steel Company. That company make use of the Conemaugh River and in dry seasons practically use the entire flow of the stream. At the time mentioned they observed that there was a great variation in the flow of the stream at different hours of the day, and an investigation of the drainage area was being made to ascertain, if possible, what might be causing this variation, which amounted to, as I recall it, about 40%; the measurement taken in the morning exceeding the evening measurement by that amount. There were no operations within the drainage area which would account for this great variation in flow, and the loss by evaporation seems to be the only way to account for the difference.

MR. BLISS.—The evaporation figures would seem to be extreme in this particular case. I have known of one case where they attempted to account for a similar problem, and it was accounted for by the stream being fed by intermittent springs which did not flow evenly. That is, they flowed stronger at one period of the twenty-four hours than at another. Just why, I do not know. For instance we do not know why geysers flow intermittently, and other ground waters which come to the surface.

MR. NICHOLS.—Do I understand you to say you do not understand the reason for the intermittent flow of springs?

MR. BLISS.—No, I am sorry to say I do not.

MR. NICHOLS.—I do not know that I do either, but when I was a boy, I used to think it was the syphon effect of a syphon outlet.

MR. BLISS.—Take a place where it varies with the time—I do not mean the intermittent time where it would gradually decrease for several days and then increase again, for we have geysers that increase for a certain length of time and then decrease, and perhaps stop altogether for a while.

MR. NICHOLS.—That was on account of the syphon principle which the discharge of a spring has, going up and down in the form of a syphon; as the reservoir filled it to the top it started to run over, and when it discharged to a point where the air was admitted, it would stop and permit the reservoir to fill up again.

MR. BLISS.—I see, thank you.

MR. CHEYNEY.—The Conemaugh River at the time referred to was extremely low and the water was very shallow. The stream bed was filled with stones and boulders which projected above the water surface; probably 50% of these boulders being exposed to the air. The direct rays of the sun upon these boulders in the shallow stream undoubtedly raised the water temperature to a comparatively high point, and the evaporation was no doubt very great on this account.

MR. W. P. DALLETT.—This same action is seen in wells that flow. I have seen a hydraulic ram operating on a well in Camden getting its water under pressure from an artesian well, and at times of new and full moon we find the pressure falling off and decreasing during the day in rhythm with the tide—not exactly the same time as the tide, but in rhythm with it, and at other times of the month the operation is very much less.

PAPER NO. 1120

STEREO PHOTO SURVEYING

By HENRY HESS

Read February 1, 1913

Certain work that I was engaged in some time ago developed the need of special optical apparatus, the design of which took me to Jena, to the famous Zeiss concern. Dr. Pulferich, the Chief of a certain section, showed me some apparatus that will, I believe, be of interest to all of you, and possibly more particularly to the civil engineers and architects among you.

Would you be interested to know that you could take two stereoscopic photographs of a building from diagonally opposite diagonal viewpoints and then from these, in the quietude of your office, construct as correct a ground plan as would be possible to you with the most careful work in the field?

Who among you has enjoyed the experience of making surveys in heat and cold, in rough, broken and most difficult country? Would you call it a pipe dream were it suggested that all you needed was a camera, and that you could do most accurate plotting at your convenience and with every comfort in your office from the photographs taken in the field? And that you could devote the open season to photographing every possible territory for, say a projected railway, and then pick out the best from plottings made in your office?

And if you would call that a pipe dream, what would you say of a person who suggested that you could take photographs from mountain tops and balloons and save yourself all the troubles of climbing

over hills and through valleys, but instead sit comfortably in your office over your photographs and special apparatus and not only plot out your contours, but easily prove for correctness from a complete new set of observations without moving out of your office?

Some of you are more or less interested in affairs astronomical. What do you say to using similar apparatus for plotting and sur-

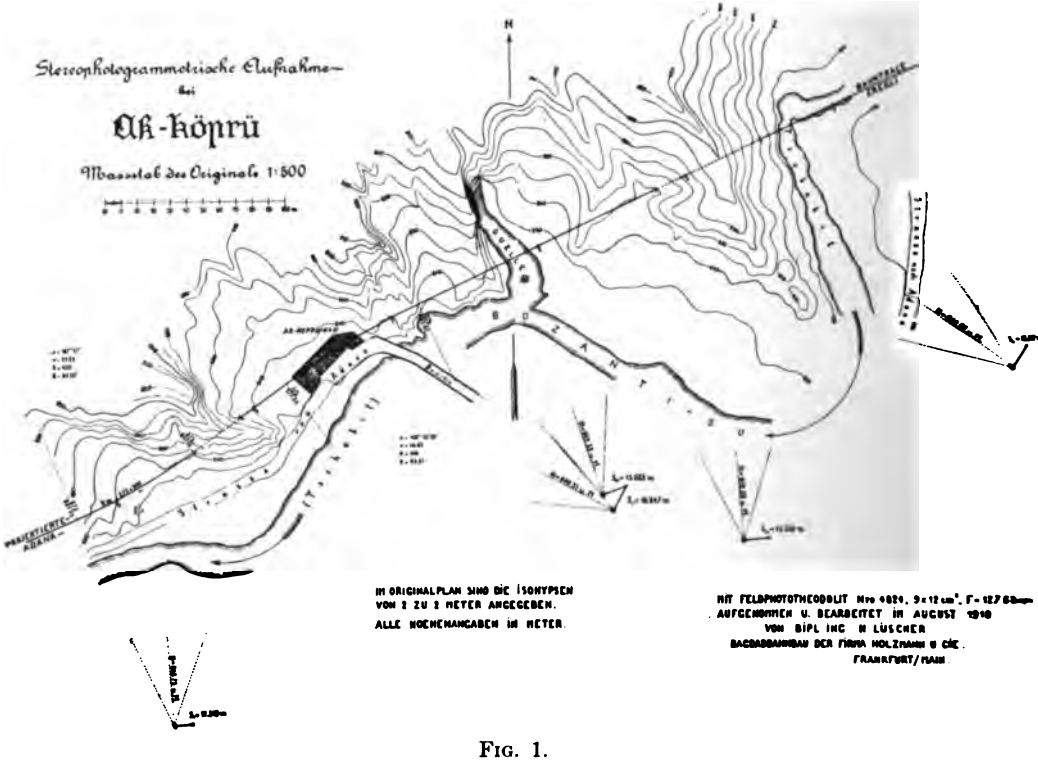


FIG. 1.

veying the heavens, measuring star movements and checking astronomical calculations by relatively simple apparatus?

Coming back to earth again, what do you think of an application of the same apparatus adapted to automatic portrait sculpture?

But enough of questions! Results are what you want!

This first picture is what the Zeiss people euphoniously (Fig. 1)

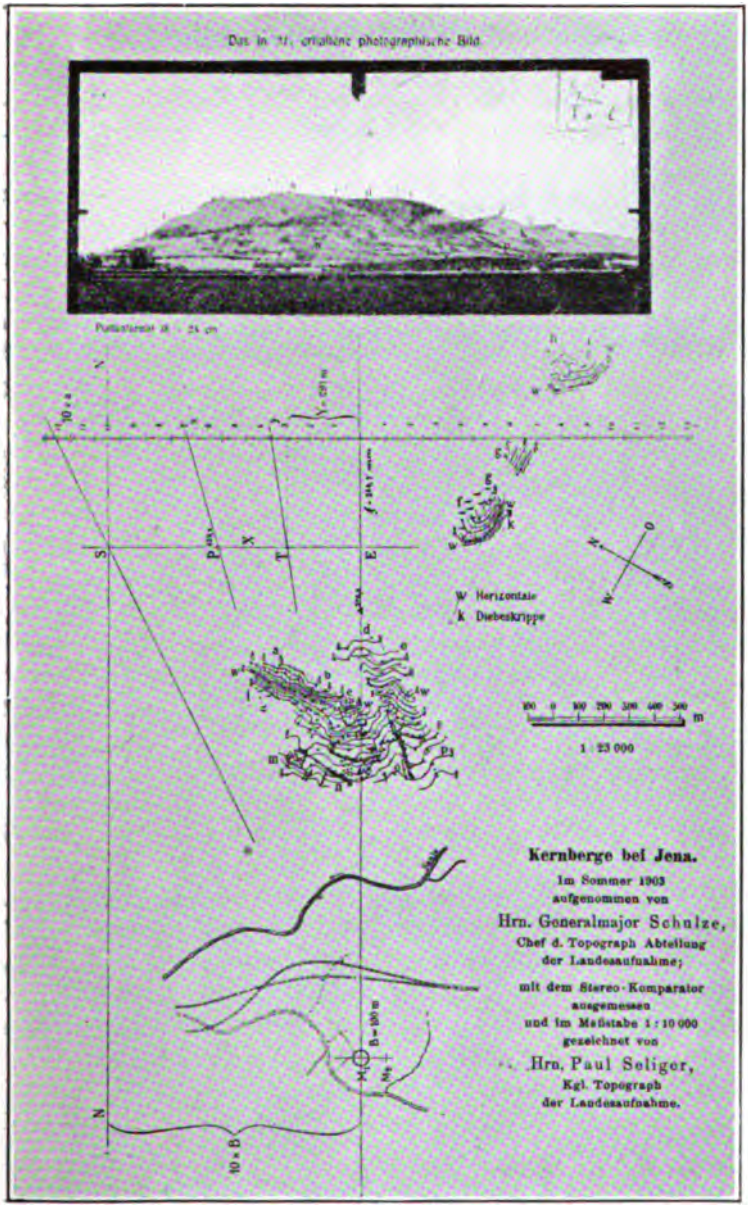

Das in N. erhaltene photographische Bild
W Horizontale
k Diebeskrippe
1 : 25 000
Kernberge bei Jena.
Im Sommer 1903
aufgenommen von
Hrn. Generalmajor Schulze,
Chef d. Topograph Abteilung
der Landesaufnahme;
mit dem Stereo-Komparator
ausgemessen
und im Maßstabe 1 : 10 000
gezeichnet von
Hrn. Paul Seliger,
Kgl. Topograph
der Landesaufnahme.

FIG. 2.

miscall a "stereophotogrammetric survey "near Ak-Köpra" made in 1910, in connection with the Bagdad railway project. Each contour line represents 10 meters—32 feet. In the original, contours were established for each 2 meters — 6½ feet. The levels range from 830 to 920 meters, 2,723 to 3,018 feet, a difference of 90 meters (295 feet).

This fact, that without extra work the stereophotos give you any number of plotting points, is very valuable, particularly when you have reason to suspect an error and need a few more plotted points. That is the time when you would, paraphrasing the Wyomingite, shout to have the Photo theodolite brought your way. It was a Texan at the convention who spouted: "We represent the great State of Texas. The first white woman born in Texas is still living—she has now a population of over three millions!" Instantaneous was the response: "Send that woman to Wyoming—we need her!" This section of road is about 570 meters (1870 feet) long. The photographic survey was made from five stations.

We have next a topographic survey of some mountains near Jena (Fig. 2) and above that one of the stereophotographs.

The study of glacier movements and changes has engaged the attention of many geographers and climatologists. The Austrian Government is engaged in the work of charting certain glaciers from time to time as a basis for this study. That work is facilitated and made less costly by this photographic method of surveying, which has the great advantage of not calling for the physical presence of surveyor or assistant at inaccessible points. Provided only that stereoscopic photographs can be made of them, the most naccessible cliffs yield their contours as readily as a flat meadow.

This color slide is a reproduction of the stereophotogramm (Fig. 3) of the Goldberg Glacier and the surrounding mountains as published by the Austrian Military Geographic Institute. This color transparency, by the way, has been made by the latest development of the Ives process of color photography that I was privileged to announce as on the way in my address of about a year ago.

You will recognize the upper portion of this picture as (Fig. 4) a distant view of a fleet of war vessels. Should you consider it possible

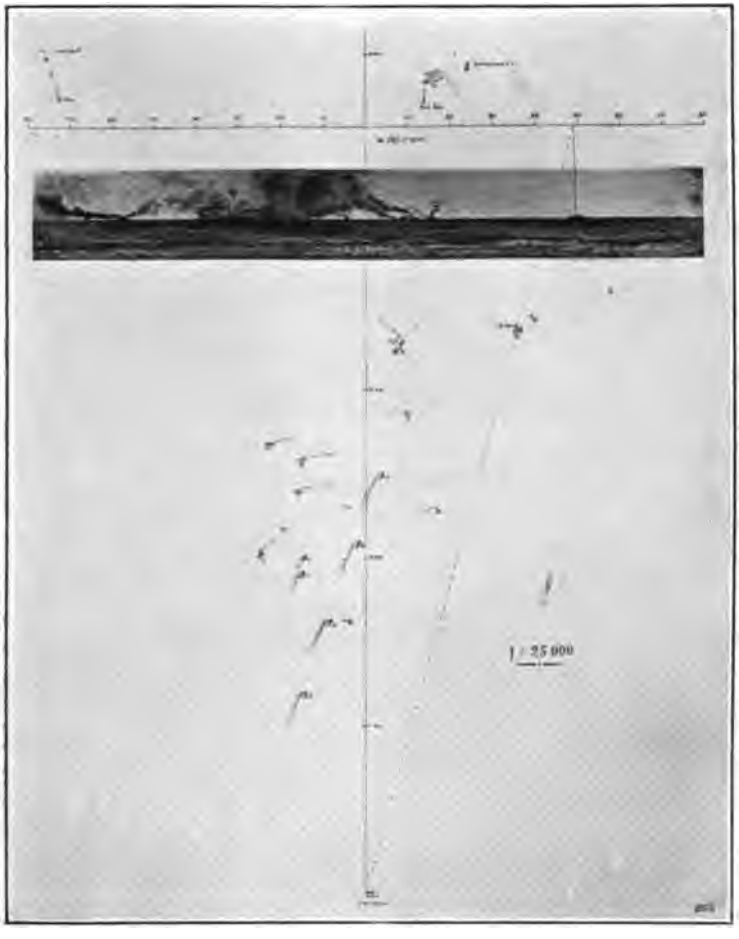


FIG. 4.

to accurately locate the instantaneous position of every one of these vessels, moving at speed, and to so locate each from aboard a vessel passing at speed at some distance? The answer is in the horizontal plot, which shows not only the position of each vessel, but also the direction of the wind. This was made possible by the use of stereo-photo theodolites on board the passing vessel.

Of what avail the elaborate precautions military authorities take against the harmless amateur with his "Kodak" when a vessel steaming by at a distance can accurately survey an entire coast range and locate in detail every coast fortification?

This picture, which was taken in Kiel Bay, recalls to my mind a wave contour map of that harbor.

Have any of you ever tried to take a picture of a wriggling baby? Probably not, but some there are among you, who, of course solely in response to Rooseveltian promptings, have manfully done your duty and have then, to carry proof of your success to your suffering friends, helped your proven better half and the photographer with dangling teddy bears to charm the infant hope to sedateness of behavior, at least long enough for the camera man to shoot.

Now what would you do when confronted with the task of charming the wild waves to allow you to make a contour map of the face of Mother Ocean? You would give it up unless you knew of "Photostereogrammetry," and then you would take a stereosnapshot and do your plotting comfortably at home in the companionship of your pipe instead of a teddy bear.

I was shown a contour map of the waves in Kiel harbor made in connection with a study and systematic gathering of data for the building of an extensive system of harbor improvements.

A while back I referred to architectural surveys The slide shows two stereophotos, of which two pair were taken (Fig. 5) to form the basis for plotting the ground plan and elevation of the building. Now from these two stereophotographs, the upper the left, the lower the right hand one, there were plotted the front elevation and plan of the building and grounds on this next slide. (Fig. 6) A checking by actual measurements in the ordinary way showed average differences of only 3 cm. +, about 1¾ in., in elevation and in ground plan. This compares well with the probable error as calculated from the characteristics of the lenses and the base line of 4.58 meters (15 ft.).

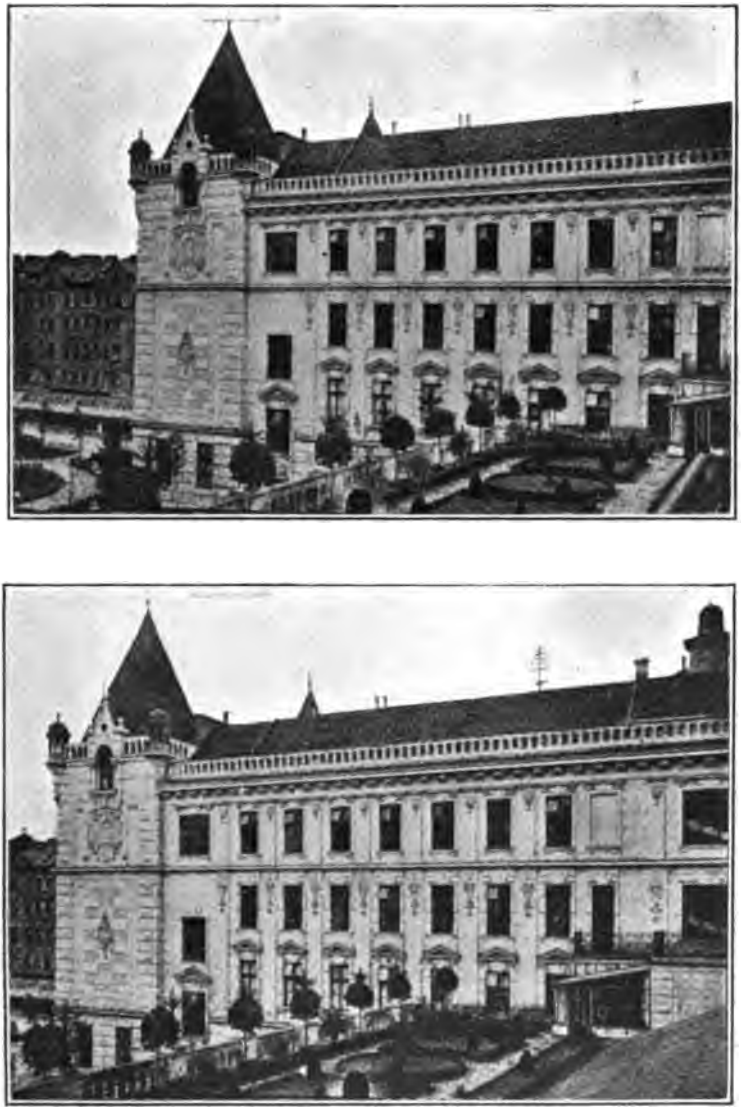


FIG 5.

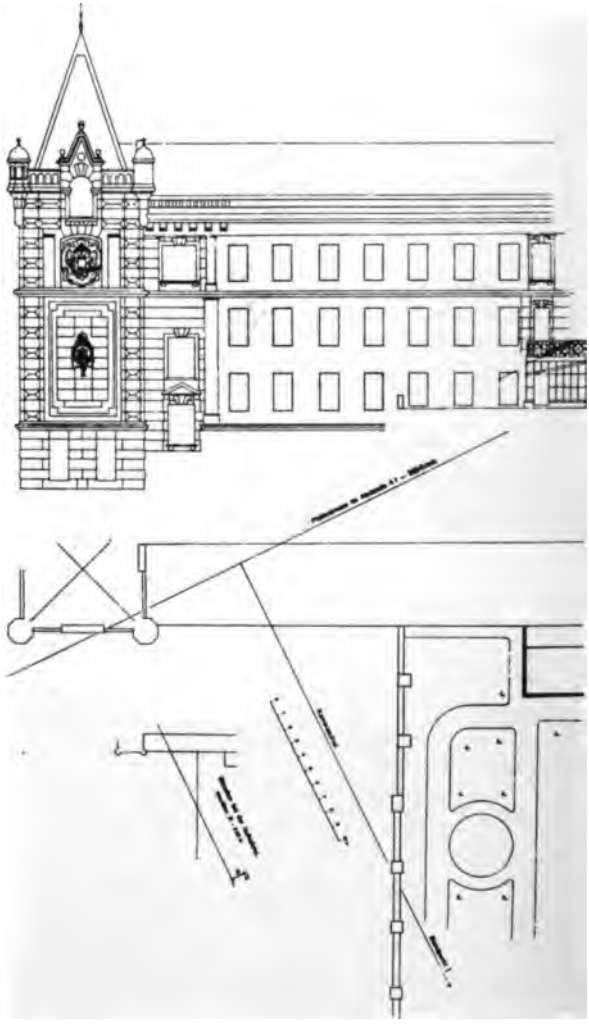


FIG. 6.

This slide shows the Peoples Building of the Carl (Fig. 7) Zeiss Foundation in Jena. The ground plan was plotted from two sets of stereophotos. This Zeiss establishment is a rather socialistic affair. Once a workman is in its employ for two years he cannot be discharged for any reason unless given a sum equal to a certain number of years'

FIG. 7.

full pay. Its officials are employed for life. They also cannot be discharged, although they may leave if they wish to. Among these officials are a number of scientific co-workers of the first rank as investigators, such as, to mention only a few of the forty or more, Dr. Schott, to whom the world is indebted for the celebrated Jena glasses, known to astronomers, oculists, microscopists and chemists; Dr. Siedentoph, whose origination of the ultra microscope has made visible and almost measurable the ultimate atom of matter; Dr. Pulferich, who has developed these photo theodolites and related instruments and many more. This establishment justly prides itself on having proven the baselessness of the oft repeated assertion that socialistic co-operative work must lack the incentive to be found in the prospective greater gain of individualistic effort. From the Zeiss establishment has come much of the advance in its field of optics and optical apparatus and out of its portals issues the best of work, in some details unequalled work; it is but fair to the far-sighted projector of the enterprise, Dr. Abbe, who placed it on its communistic basis, to believe with him, that the inherent tendency of man to do the best work that is in him would be furthered rather than held back, by placing mankind under conditions where it could concentrate on its work rather than on the questions of next day's or next year's means of living.

You will recognize the main portion of this picture as a portrait. (Fig. 8) It was drawn by the laying down of contour lines from a set of stereo photographs, all determined by exactly the same methods in use for topographical surveying. The field here is a portrait bust of Moltke and the topographical levels differ by fractions of an inch only. A portrait bust was selected as a test specimen because it permitted of accurate measurements by other methods. No errors exceeding 1-32 in. were found. Note the profile at the side and the horizontal sections at nose and forehead levels. Dr. Pulferich showed me a portrait bust that he himself made of Mrs. Pulferich in almost life size. As I was told by others also that his lady was satisfied with it, that satisfaction would be accepted by your wives and sweethearts as fair evidence of the quality of the work. The method followed is the building up of the entire bust from profile planes and fairing these by filling in the steps. A process very similar to that followed by the builder of ships models from horizontal and transverse section contours.

A pantographic apparatus carrying milling cutters and guided by the stereophotographs is, I believe, in contemplation for portrait sculpture. When it is out, we will all be able not only to "kodak" our nearest and dearest, but to "stereoscope" them as well.

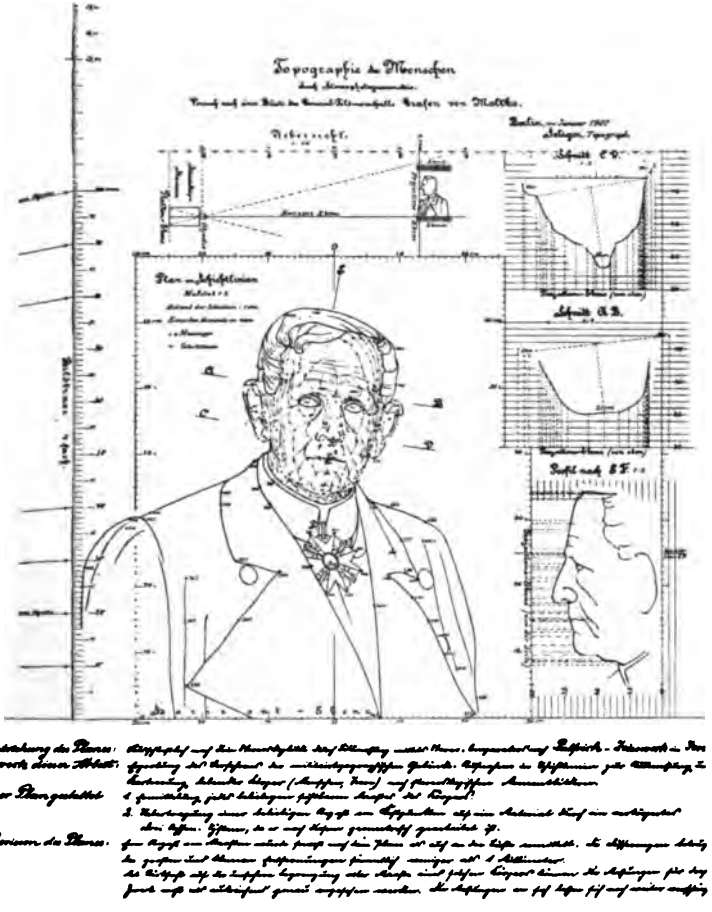


FIG. 8.

The camera required does not differ in principle from the ordinary stereoscopic camera; naturally it is constructed with far greater precision. To go into the details would lead us too far.

The Stereo-Comparator, however, with which the plates are ex-

plored and the survey measurements made on these plates is probably of sufficient novelty to earn me your pardon for taking up a little more of your time.

This slide illustrates two stereograms of a building. (Fig. 9) The horizontal line crossing both establishes the altitude base line. Some of you have your surveying days so far behind you that you may need a little freshener as to such terms as "altitude." The latest definition is brought down to the understanding of the youngest Junior before me, proud of the first pinfeather pricks on those lips that let us hope are as virginal as those of the erstwhile prophet Dowie's unkissed son. It was at an aviation meet that a youngster athirst for knowledge addressed to the blue-coated guardian: "Say, is it the altitude prize they're trying for now?" "Altitude, hell! It's the height prize." But to return to our slide: The vertical lines are a distance apart equal to the distance between the centers of the two lenses. Thus they represent vertical planes in parallel lines of sight placed edgewise and normal to the base line.

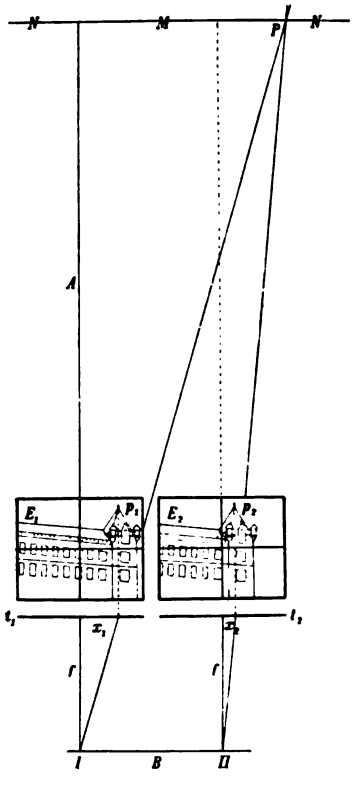


FIG. 9.

Now note the tower points p_1 and p_2. They are at different distances from the reference verticals. This difference is proportional to their distance from the observing station. The geometry is made clear by an inspection of the horizontal plane diagram. I and II are the two lenses or observing stations, N M N is the distant plane in which the tower lies, ff are the parallel lines of sight and P is the tower point; t_1 and t_2 are the two photographic plates on which appear reduced images of the field of view, in this case the building. A line of sight from I to the tower in the distant field NN will intersect the

left hand plate at distance X_1 from the normal or reference line f; on the right hand plate the intersection is at the much shorter distance X_2. A little consideration will show that the difference between X_1 and X_2 is proportional to the distance of the tower from the observer. In order to measure the distance from the observer, it is therefore only necessary to measure the difference between points p_1 and p_2 on the two plates from the reference vertical.

In the field the surveyor's tape line is used to make measurements and a division into inch units is close enough. But now the two plates constitute a miniatural field, and this must be explored with a similar, but miniature tape line, in which fractions of a thousandth of an inch are the units. That means micrometric measurements. It is here that the stereo-comparator comes in. This is a binocular microscope conveniently arranged for the specific purpose.

Consider this slide which you will recognize as a rough perspective arrangement of the last one. (Fig. 10) A M and A M is a double reflecting microscopic system, arranged like the ordinary stereoscope, n which latter, as you are all aware, the two pictures will appear as one, no longer as a flat picture, but showing the object in relief. The only purpose in substituting a microscope system for the ordinary simple superposing system of the common stereoscope is to secure enlargement that will permit the making of measurements. The two plates are placed in a frame and so aligned that the horizontal and the two verticals line up with lines fixed in the plane. In a second frame there are two pointers M_1 and M_2 at a fixed distance from one another equal to the distance between the reference verticals. These pointers are movable in the direction, and only in the direction, of these reference verticals. The two pictures will appear as one and the two pointers will also appear as one pointer, which will however apparently lie in the infinite distance behind the building.

Now move the plate frame crosswise by means of micrometer S. This will give the appearance not of a movement of the plate, but apparently the pointer M will come forward out of space toward the buliding. The plate movement is continued until the pointer is apparently directed over the tower point. A reading is then taken of the micrometer and this reading is proportional to the desired distance of the tower from the observer. Similarly the position of any other portion of the object is found, with reference both to the horizontal and the vertical base lines.

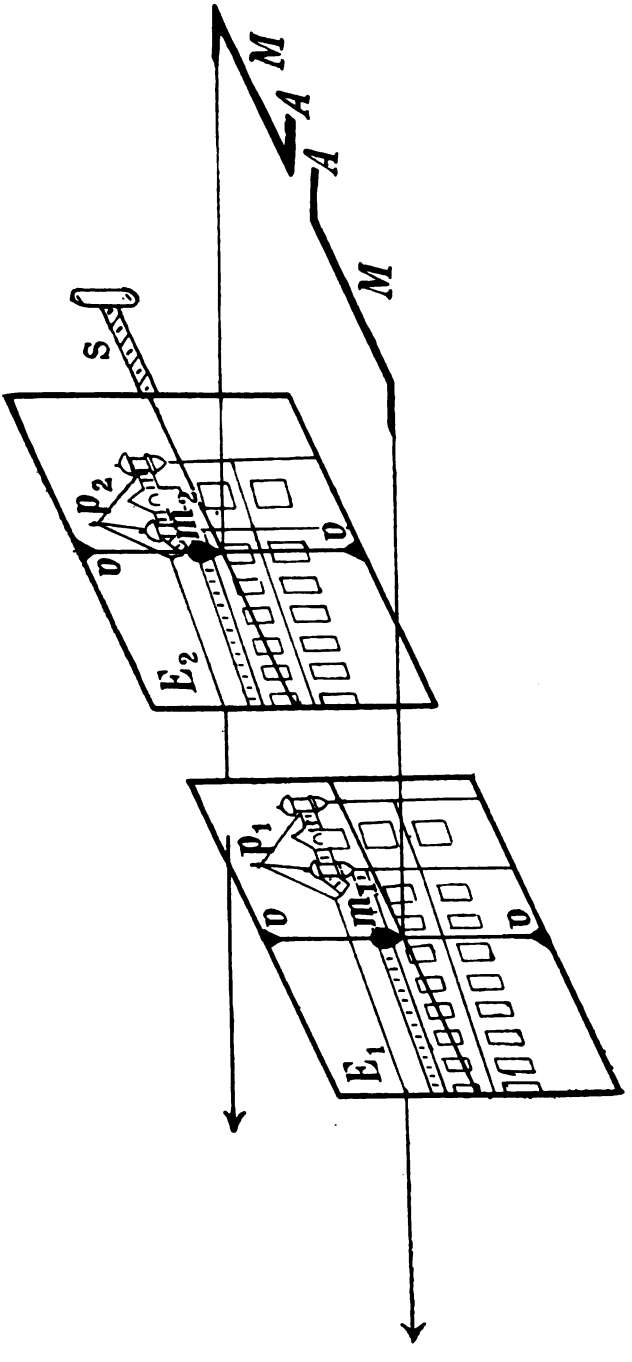


FIG. 10.

I have here a stereoscope with a measuring frame illustrating this principle, which you can inspect later on in the evening.

This measuring frame is placed on the stereoscope illustrating the principle is shown by this slide. (Fig. 11) You will recognize the two lenses and the stereo pictures contained in the circular outlines. The frame with the pointers and the micrometer screw are all easily recognizable. This simple apparatus refined with the necessary

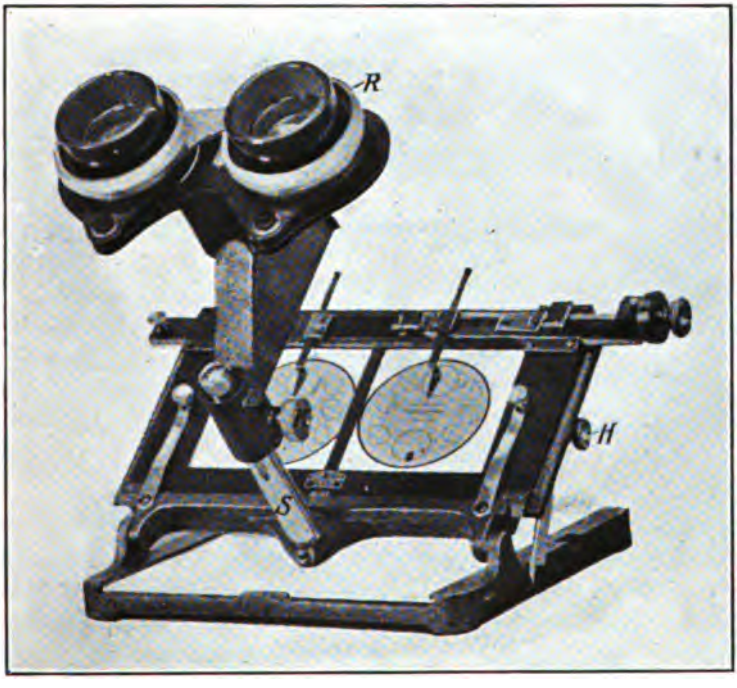


FIG. 11.

microscopes and micrometers takes on the appearance shown by this slide. P_1 and P_2 are the two plates or pictures reflected by prisms K_1 and K_2 to the eye pieces O_1 and O_2 of the binocular microscope. (Fig. 12) Scales and verniers X and Y serve for setting the pictures in accordance with the baseline and range lengths, while micrometer wheel L serves for the exploration with the pointer and the reading of the plotting point relative locations in space.

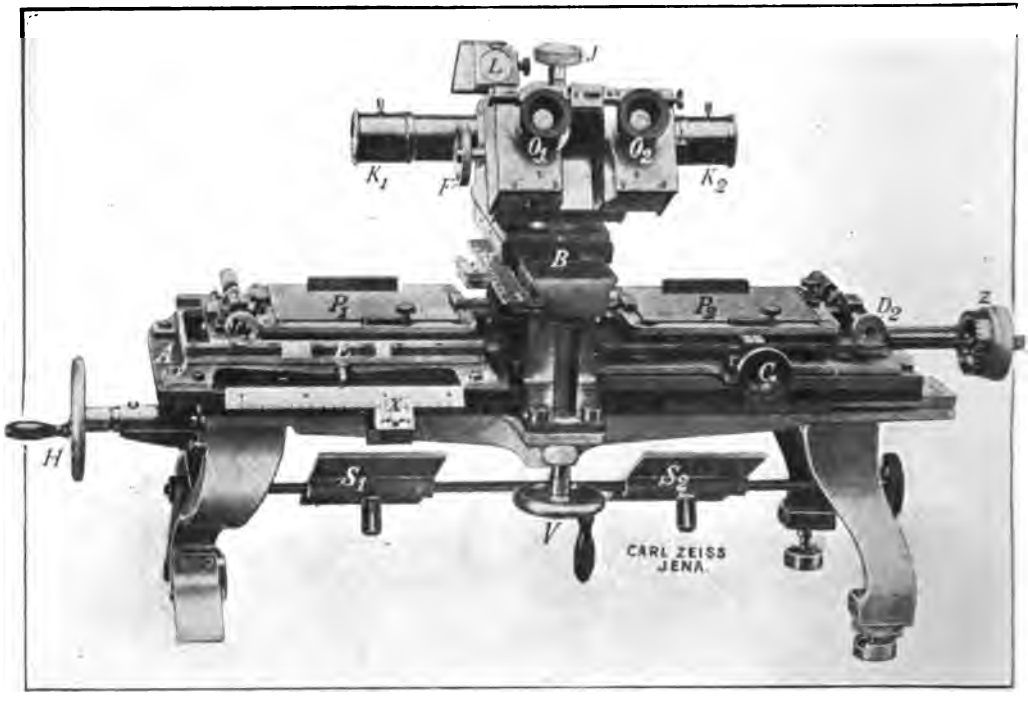


FIG. 12.

The cameras are of many varieties suited to the work in hand. This slide shows in section a field photo theodolite, such as is used for photographic surveying. (Fig. 13) For moving objects, two such instruments a fixed distance apart are used with plates simultaneously exposed. For stationary objects or very long base lines a single instrument will usually be transported from one observation point to the next. Naturally the longer the base line, the more accurate the results, just as in survey work using the older methods.

In this connection these stereograms of Saturn may prove of interest. (Fig. 14) On the screen the two pictures simply show a lot of bright specks on a dark ground. A close inspection will show that some of the specks occupy relatively different positions. Each speck is a star; those that are fixed are so far away that no change in their relative position is observable. The photographer, after taking his first picture, had to shift his base 96 million miles for his

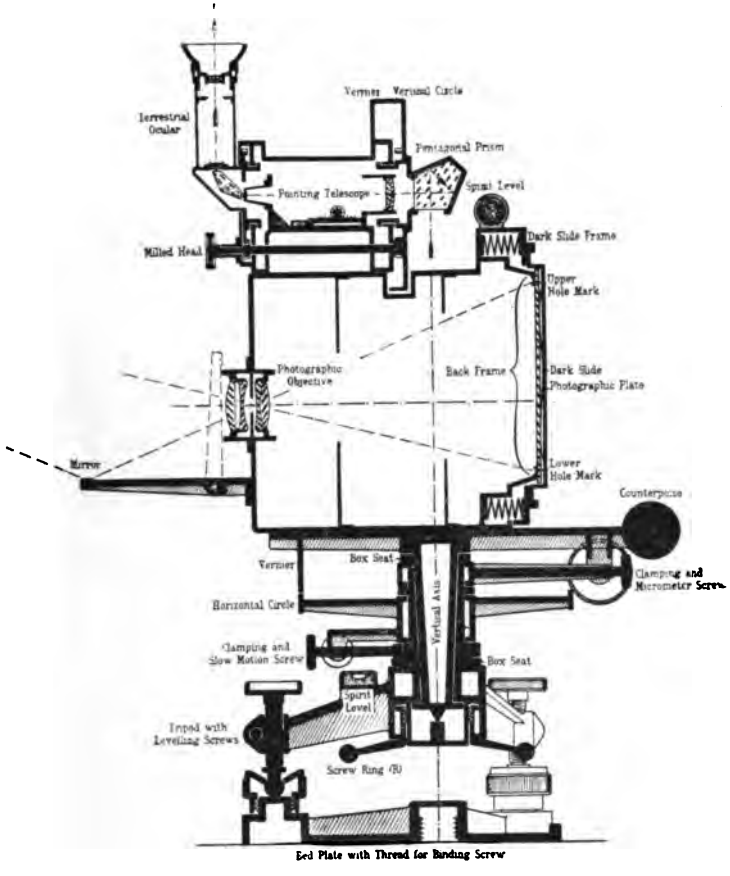


FIG. 13.

second; and he found it easy to get there in just 23½ hours by using old Mother Earth instead of a "Ford," she moving just that distance in that time relatively to Saturn. If, later, you will look at this slide in the stereoscope, you will see Saturn afloat in the hollow dome of the fixed stars with his moons before and behind him and many lesser luminaries suspended in space at various distances. Stereophotographs quite similar to these, but taken at intervals of years and corresponding base lines of thousands of millions of miles are now being used to measure astronomical distances and motions and to check and correct the mathematical determinations.

While the astronomer thus uses the apparatus for his enormous interstellar distances and the surveyor for his ordinary earth surface mensuration, the same apparatus is equally applicable to the measurement of the almost infinitesimal. It was a problem of the latter kind that brought it to my attention. I wanted to determine accurately the change in shape of a ball when loaded; not simply the reduction in diameter in one direction and the increase in diameter normal to that, but the slight change in the entire cross section and under such light loads as permitted of elastic recovery. That meant the photographing of the ball at intervals while under load and while recovering on removal of the load. That involved also great photographic difficulties in securing a sharp silhouette for the two stereoscopic pictures necessary for each successive exposure, sharp enough to permit the measurement of changes of shape less than a twenty thousandth part of an inch. Dr. Pulferich of Zeiss at first declined the job as impossible, but did finally arrive at a solution with the aid of a slightly modified stereo-comparator.

I thank you for your attention and hope that I may have aroused your interest in an apparatus that deals with the mile multiplied thousands of millions of times and as readily subdivides the mile into thousands of millions of measured parts.

Now, some of you count their most pleasant recollections the days when they were out with the boys in the untrammeled wilds, toting a rod, or as they tell it now, squinting through the telescope. You will object to thus substituting the soulless and unromantic camera. but there is always a common ground on which two men having the most diverse experience and opinions are at one. Witness the fellow who disagreed with the "heart to heart" column editor in insisting that elopements never could turn out happily and insisted that they did because his elopement was still the cause of his enduring joy in life; his neighbor agreed most heartily, saying that he too had found no end of happiness, quiet, comfort and joy, when his wife eloped with another chap.

A year ago I was privileged to address you and I used that occasion to ring in two subjects on you just as I did tonight what between the opening part on the Affairs of our Club and this closing part on the Stenogram.

Possibly I would not have been content with that, for I do dearly love to get a chance to talk where no one can decently choke me off,

but I was afraid that my successor in the chair might remember the story of Levy's wife. For fear that he might tell it in the discussion that will soon be opened for your getting back at me, I shall tell it myself.

Levy was a noted conductor who believed in Bull Moose families long before the great Bull Moose bellowed through the land. One evening when his baton was in full swing a boy jumped out from under the stage with: "Misther Levy, Misther Levy! Your woif has just had a baby!" "The Lord be praised," said Levy, still waving his baton. Soon the boy popped up again. This time the baton wabbled a bit under its wielder. "Is there anything wrong, boy?" Well, Missis Levy's had another baby!" This time, Levy dropped his baton, shouting: "It's high time I got there and put a stop to the performance!"

(Copied from The Philadelphia Photographer of December, 1866).

SURVEYING BY PHOTOGRAPHY*

By Benj. Smith Lyman

The interesting paper in the November number of the *Photographer*, by Dr. H. Vogel, on some modes of applying photography to surveying, makes me wish to suggest one or two other methods of such an application, that occurred to me three months ago.

These methods would be especially adapted to the panoramic apparatus described by Dr. Vogel, but could be used, with easily made corrections, with lenses, like the Globe and the Zentmayer, that give a wide flat field. The camera should be fitted with spirit-levels; and so adjusted that after the exposure, a vertical and a horizontal line passing through the optical axis, can be drawn with a fine point on the collodion film, by the help of a little apparatus that marks the ends of the two lines, while the plate is in the camera. The adjustment of this apparatus to the optical axis would be similar to that of the cross hairs in the surveyor's telescope. Then, if it is desired to take but one photographic view, a large number of rods, say ten feet long, must be provided, painted black and white in alternate feet; and these must be set up at the important points in the landscape. It is plain, that in the picture, these rods will appear of different lengths according to their distance. They can be measured by a micrometer, either their full length or such a number of feet on them, as may be left visible by the vegetation or other obstacles, and also the distance from their base to the vertical and horizontal lines. The measurement of the length gives the distance of each point from the camera, reckoning the diminution in size proportionate to the distance. The distance, then, from the vertical line in the picture,

---

* Your Publication Committee thought that this article might be of interest to the members, as it shows that Photo-surveying has been thought of for some years, hence its appearance with Mr. Hess' Paper.

divided by the length of a foot on the pictures of a rod, gives the real distance in fact of the point from the vertical plane of the optical axis. With the distances from the observer and from this plane, the different points can be plotted on paper. Moreover, the level of each point can be determined in the same way, by the distance measured on the picture from the horizontal line.

In case the panoramic apparatus were not used, the measurements made at a distance from the centre of the plate could be corrected by coefficients theoretically or experimentally determined; or they could be mechanically corrected in plotting. For the increased size of the objects at a distance from the centre, and their consequent greater apparent nearness could be corrected for the direction parallel to that axis from a line drawn through the camera station, at right angles to the optical axis, instead of measuring from the camera direct. Or both micrometric measurements may be corrected by plotting the two uncorrected distances from the camera, and from the line representing the vertical plane of the optical axis, and then producing the line from the camera, until it reaches a distance from the line drawn through the camera station at right angles with the optical axis, equal to the uncorrected camera distance.

The trouble of making and setting so many rods, and the danger of omitting to set them at points that may prove to be important, may be avoided by taking two views. A base line of ten, twenty, fifty or any other number of feet must be carefully measured, and a camera placed at each end of this line, with the optical axis at right angles with it, so that the two views shall be exactly parallel. The parallelism may be accomplished through a pair of sights accurately adjusted upon the camera, by which you may sight, from the station at one end of the line, at a plumb line held over the other station. Or a line of indefinite length, fifty or a hundred feet or more, may be laid off by the help of other instruments, at right angles with the base line from each end of it, in the direction of the views, and the camera may then be so set, that rods placed at the far end of these lines, shall, in each view respectively, send their image upon the vertical line of the glass plate. With two views taken in this way, the distance of each object in the landscape can be measured by a micrometer from the cross lines on the plate; and the difference between the two measurements to the vertical line in the two pictures would give the apparent length of the base line, ten, twenty, or fifty feet,

at the distance of the object forward from the camera. This length would be inversely proportioned to the distance, and this distance could then be plotted in a direction at right angles with a line representing the base line. Then the distance of the object on the picture, from one of the vertical lines, divided by the apparent length of the base line, would give the plotting distance to be measured off parallel to the base line, from the point on the paper just obtained. The plotting, then, would be done by means of two rectangular co-ordinates, the ordinates and abscissa; the apparent length of the base line at the distance of the object, giving one co-ordinate, and the micrometrically measured distance of the object from the vertical line, divided by the apparent length of the base, giving the other co-ordinate. The level may be got in a way similar to this last-mentioned co-ordinate, by measuring the distance from the horizontal cross-line, and dividing by the apparent length of the base.

If the panoramic apparatus be not used, corrections of the measurements must be made in the same way as mentioned already for the method with a single view, either by a coefficient or by mechanical construction. After plotting a point without correction, a line may be drawn through it from the intersection of the two cross-lines on the paper (the base line and the one representing the optical axis), and prolonged until it reaches a distance from the base line produced equal to the distance of the point from the intersection of the cross-lines.

It is evident that the base line may be made vertical as well as horizontal; that is, the two pictures may be taken, one a certain distance exactly above the other, as, for example, from the upper and lower windows of a house.

Of course, the larger the pictures the greater the distance to which the measurements can be carried with accuracy.

Although paper copies of the pictures would be unfit for making the measurements, yet they would be useful for keeping a register of the measurements made on the glass plates.

These photographic methods of surveying would plainly be applicable chiefly in an open country, but in a wooded region lines might sometimes be cut through the woods and marked by rods, as in the first method, and yet time and labor be saved to the surveyor.

PHILADELPHIA, Nov. 11th, 1866.

MAP OF PHILADELPHIA AND VICINITY ~ SHOWING SYSTEM OF RAPID ROADS

FIG. 1.

PAPER NO. 1121

THE PLANNING OF CITY STREETS

By B. ANTRIM HALDEMAN

Assistant Engineer, Bureau of Surveys

Read December 7, 1912

The average citizen, and even the citizen who takes an active interest in public affairs, seems to give but little thought to the street system; he accepts, without question, whatever is provided, whether the streets be wide or narrow and whether the general scheme be a wise or wasteful one; he is perhaps justified in his indifference and saves the planner embarrassment by it since even the authors of the plans themselves seem to have only a hazy suspicion of the importance of the work and perform it in a purely perfunctory manner without pausing to ask or answer the pertinent query "why are these certain arbitrary widths and cross-sections established?" or, if the query does suggest itself, reply to it without any serious attempt to investigate or analyze the problem; this seems to have been the case in the past as witness the extremes of street planning—Boston with its irregular system of streets averaging less than fifty feet in width and Salt Lake City with its severely regular system of streets one hundred and thirty-two feet in width, and between these extremes every scheme that can suggest itself to the mind of man.

The statement that the planning of a city's street system is the most important problem municipal engineers are called upon to solve is one which would probably challenge immediate denial on the part of those members of the profession whose minds are absorbed in the study of water supply, sewerage disposal, transportation, and harbor improvements, but when the subject is viewed at close range, with all the complex conditions surrounding it and all the varied interests depending upon it, the statement may be found to contain a large element of truth.

The expenditures for the construction and maintenance of streets

are among the largest items in the municipal budget and the investment is one which can return no direct profits. The street enters constantly and intimately into the daily life of the citizen and is absolutely necessary to his comfort and convenience; the economical construction, maintenance, and operation of every other public utility depends upon the street, but none of them receive so little really intelligent thought or skilful attention and in none of them is there a larger opportunity, or one more neglected, for the practical exercise of economy; the most expert engineering skill is called to the planning of other public works but the planning of the street system, until quite recent years, has generally been done in a perfunctory manner by the municipal officers charged with the duty or left to the tender mercies of the real estate operator; long established custom or the force of habit have controlled in the one instance and personal interest in the other.

With the rapid growth of our cities, a growth that shows little sign of abating notwithstanding constant pleas to the people to turn back to the country, and the ever widening circle carrying urban development over large areas each year, the cost of street opening and improvement under the arbitrary and unscientific methods of operation which have heretofore prevailed has become a serious problem which calls for solution along more deliberate, rational, and economic lines.

But this problem could not be forever ignored in the march of modern progress and a new era in this important branch of municipal engineering has dawned; examples have been set of practical, progressive, premeditated town planning and a new, modern school of town planners is growing up and making its influence felt. Town planning is not a new science, for it has been practiced to some extent by wealthy and luxurious nations for centuries, but it has been lost sight of and neglected in the intense industrialism and commercialism of the Nineteenth Century; the wealth created by this industrialism and commercialism has brought with it the desire for finer cities, more attractive environment, and better, easier, more comfortable, and more healthful conditions of living; and not only the desire, but the necessity, for the wealthy will naturally surround themselves with luxuries, and, remembering the fate of luxurious nations that have had their rise and fall in the past, the raising of the standard of life and living among all classes of the people has become

FIG. 2.

a social and economic problem of vital importance in maintaining national character and in perpetuating national identity.

Modern, scientific methods of street planning have been employed to a much greater extent abroad than they have in the United States. The Germans have been very industrious and very ingenious in adopting advanced principles in rebuilding and extending their cities, and have written voluminously of their theories and practices; in England, Parliament has created a general Town Planning Act; much creditable work has been accomplished and some of the universities have added a course in town planning and civic design to their curricula; some of the best books on the subject have been produced by English authors; America is awakening to the advantages to be derived from more skillful planning, as is shown by the number of towns and cities which have employed specialists to sugges tchanges and improvements; an Act of Assembly of the Commonwealth of Pennsylvania approved June 10, 1911, authorizes the creation of a Department of City Planning in cities of the second class; a civil service examination for a town planning engineer was held in the city of Newark, New Jersey, a short time ago, and it is entirely probable that this will become a special branch of municipal engineering in all our cities.

The planning of streets is the first, if not the most important, problem in the origin and growth of cities. The very first step in the creation of a town or city is the preparation of a plan of its streets, for without streets, or public passageways serving as such, there could be no city; therefore, the streets may fairly be considered the foundation upon which the city, with all its countless activities, rests, and unless the foundation shall be properly proportioned and constructed the structure reared upon it will be subject to the constant menace of failure, decay and ruin. Every engineer will admit that the stability and the durab lity of the structure he erects depends upon the integrity of the foundations beneath it; therefore, the modern city, being the greatest and most comprehensive of the works of man, representing in its purposes and its accomplishments the ambitions and the triumphs of human energy along every avenue of science, industry and art, should have a foundation broad enough, and sound enough, and substantial enough to bear the ever increasing burdens the passing years lay upon it.

The large importance of the street lies in the fact that the entire

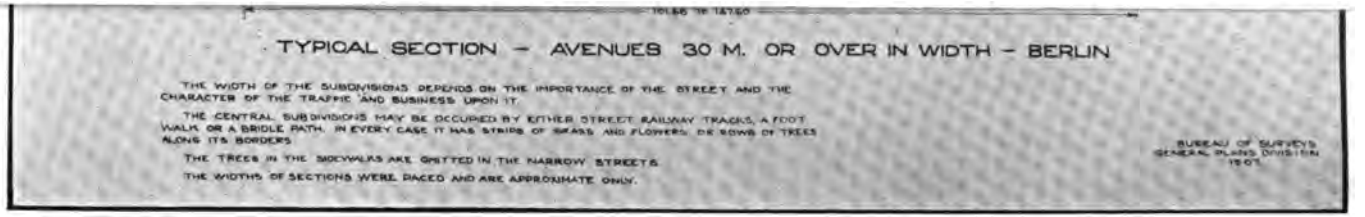

TYPICAL SECTION – AVENUES 30 M. OR OVER IN WIDTH – BERLIN
THE WIDTH OF THE SUBDIVISIONS DEPENDS ON THE IMPORTANCE OF THE STREET AND THE CHARACTER OF THE TRAFFIC AND BUSINESS UPON IT.
THE CENTRAL SUBDIVISIONS MAY BE OCCUPIED BY EITHER STREET RAILWAY TRACKS, A FOOT WALK OR A BRIDLE PATH. IN EVERY CASE IT HAS STRIPS OF GRASS AND FLOWERS, OR ROWS OF TREES ALONG ITS BORDERS.
THE TREES IN THE SIDEWALKS ARE OMITTED IN THE NARROW STREETS.
THE WIDTHS OF SECTIONS WERE PACED AND ARE APPROXIMATE ONLY.
BUREAU OF SURVEYS
GENERAL PLANS DIVISION
1907

FIG. 3.

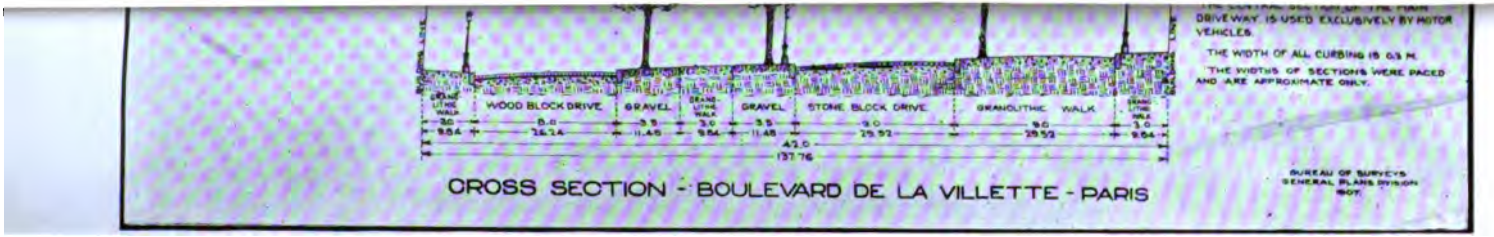

DRIVE WAY IS USED EXCLUSIVELY BY MOTOR VEHICLES.
THE WIDTH OF ALL CURBING IS 0.3 M.
THE WIDTHS OF SECTIONS WERE PACED AND ARE APPROXIMATE ONLY.
WOOD BLOCK DRIVE
GRAVEL
GRAVEL
STONE BLOCK DRIVE
GRANOLITHIC WALK
3.0
8.0
3.5
3.0
3.5
9.0
9.0
3.0
9.84
26.24
11.48
9.84
11.48
29.52
29.52
9.84
42.0
137.76
CROSS SECTION - BOULEVARD DE LA VILLETTE - PARIS
BUREAU OF SURVEYS
GENERAL PLANS DIVISION
1907.

FIG. 4.

system of transportation throughout the city depends upon it, that it is a controlling element in the development of property and the making of the homes of the people, and that it is the principal factor in encouraging and promoting the physical expression of civic art.

In approaching the subject of street planning it may be well to digress a moment and consider briefly and in a broad sense that most important agency of modern progress—transportation—for transportation and the street are as inseparable as they are indispensable in the working out of a city's destiny. The dictionary defines trans-

FIG. 5.

portation as "the act of conveying;" very simple and very plain, but the ramifications involved in this definition are almost infinite; it embraces every act or agency by which any object or substance is conveyed from place to place; applied to the street it includes every means of conveyance under, upon, or above the surface.

In ancient times the strength of nations and the greatness of cities depended on the sagacity and skill of the people in the use of the arts and implements of war; in these modern times the strength of nations and the greatness of cities depends upon the sagacity and

skill of the people in the use of the arts and implements of industry; industrialism is the impulse of the age and successful industrialism stands and grows on the sole basis of transportation; without transportation industry is localized but with it it penetrates every corner of the globe.

The power and wealth of Britain are not built upon her Dreadnoughts so much as upon her fleets which carry the world's commerce; London is great because from time immemorial she has pushed her lines of transportation over all the earth; transportation has made

FIG. 6.

New York the most wonderful city of the world, and in three quarters of a century it has transformed an open prairie into the second city of America. The tremendous development and prosperity of the United States has been made possible only through the swift improvement and adaptation of the methods of transportation. Changes have been most remarkable during the past quarter of a century; the older trunk line railroads have been practically rebuilt; enormous sums have been expended in reducing curves and grades and in other measures to permit large increases in weights, loads, and speed of

trains; large and swift electric cars have taken the place of the small, slow, horse cars, and have brought the country much closer to the city; the surface car has been supplemented by the elevated and the underground; the motor car and the motor truck, in constantly increasing numbers, are rapidly superseding horse drawn vehicles; upon the water the oar and the sail have given way to the power boat; the great clipper ships which once carried the world's commerce knew but a comparatively brief existence and have been succeeded by the huge steel steamship driven by a new type of engine superseding a type which, like the clipper ship, failed to meet the highest requirement of marine serivce; should the present experiments in aerial navigation result in the adaptation of the air-ship to practical uses it will have a more far-reaching effect upon transportation than any other influence now at work.

These highly progressive methods of transportation have been brought about by the compelling influence of industry and trade, ever seeking for new business and broader fields of enterprise; they are the symbols of progress in every nation and every community, and unless ample opportunity is offered for their adoption and use, the aggressive industrialism necessary to the prosperity of the modern state cannot thrive or reach its full development.

Speed, so far as it may accomplish the annihilation of time and distance, is one of the chief objects sought in improving transportation. Time spent in travel or transit is reckoned a dead loss in the economy of modern business and the demand for the elimination of this element of loss, or its reduction to a minimum, is responsible for the phenomenal development and popularity of the limited express, the express steamship, the fast freight, the motor vehicle, the telegraph and the telephone.

Getting back to the subject—the chief mission of the street is to provide adequate facilities for the untrammeled movement of the people and the circulation of every form of service necessary to their industrial activities, their comfort, and their convenience, and the real test of the efficiency of a street system is the facility with which transportation, "the act of conveying," may be conducted throughout all parts of a city; for direct, rapid and unobstructed means of communication are as necessary to the progressive development of a city and its industrial and commercial enterprises as direct, rapid and unobstructed means of transportation are to the trade and com-

merce of the world; therefore, the requirements of every form of urban and interurban transportation, present and prospective, must receive first consideration in any plan of streets.

Once established and built upon, the street becomes more nearly permanent than any other feature of the city. Assuming that the present era of peace and industrial enterprises will continue indefinitely, the passing of time may witness the demolition and reconstruction, one by one, of all existing business, methods of trade and transportation may be revolutionized, buildings and social customs may be

FIG. 7.

transformed, the forms and methods of every class of public service necessary to the health, comfort and convenience of the people may change, the people themselves may have new ambitions, new ideals and new activities; the tendency of all these changes will be to increase the usefulness and importance of the public highways, but no matter what changes come, or what new demand supon it may be made, so long as the city endures the street system will offer the strongest resistance to the processes of transformation; its evils will be most difficult to reform and opportunities for its improvement will become ewer as the years pass away; therefore, the best judgment and skill

and the keenest foresight of the probable future usefulness of the street should be called to its original planning.

In addition to the importance of the street as the channel through which the industrial and social activities of the city flow there are other large considerations which must not be neglected. Intelligent thought and care must be exercised in providing opportunities for the advantageous and economical development of abutting property for either public or private use, and the probable character of such development should have a large influence, but should not be per-

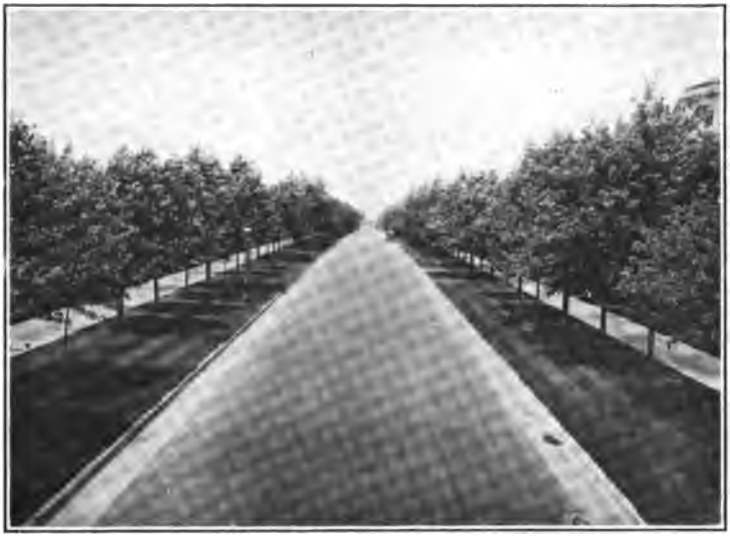


FIG. 8.

mitted to subordinate the larger purpose of public usefulness. Aesthetic effect, or the opportunity for attractive and ornate development, must also receive attention, for the tendency of the education and training of the present is toward higher ideals and a larger appreciation of art and beauty in all our surroundings.

Almost invariably the street system of a new town has been prepared by or for a proprietor or proprietary corporation and the site has been selected for the promotion of some commercial, industrial, or social enterprise. The plan adopted has usually provided only for the development of a limited area with little regard for future

expansion; if the enterprise proved successful the town gradually grew beyond the original limits of the plan and the owners of adjacent property began to lay out streets and subdivide their land, sometimes in conformity with the original plan, but more often in the manner most advantageous to their own immediate purposes and profits without regard for any existing system or future exigency. It is just here that the evils of careless, irresponsible, and ill-considered street planning beg'n to take root unless there shall be some public body with sufficient authority, foresight and skill to control and

FIG. 9.

direct the planning of extensions with due regard for public service as well as private rights.

In view of the progress that has already been made in scientific street planning and the general recognition of its merits, it is entirely probable that the best skill available will hereafter be employed in planning new towns, especially those established under such circumstances as give a reasonable guarantee of considerable future growth and importance, but our immediate attention should be directed toward the better planning of the extensions of the street

systems of our rapidly growing cities and of the detached suburban town sites which are being developed near them.

There is a very positive movement in the great cities of both America and Europe to discourage the increase of apartment and tenement houses, to reduce the tendency toward congestion of population by spreading it over the suburban areas, and to get people, particularly the working people and those of only modest means who now live in tenements, out into the open and closer to nature. The success of this movement depends primarily upon two conditions—the economical development of property to insure reasonable values

FIG. 10.

for home sites, and direct and cheap transportation to enable the people to be carried quickly between their homes and their places of employment or business. In Philadelphia, the conditions are reversed to the extent that we need fair land values and better transportation facilities to perpetuate the present system of one family houses and prevent the growth of the tenement system of living; in both instances, however, the object aimed at can only be accomplished by a more complete public control of the development of property and a more intelligent exercise of the street planning power. The abandonment of the apartment and tenement house in favor of the

one family house built with a larger regard for light, air and hygienic conditions means larger building lots and more open space in our cities, and this, in turn, will necessitate the exercise of greater economy in street planning, and especially in the distribution of paved areas upon m nor and residential streets.

The first problem which should be considered in plotting a street system is the establishment of main traffic routes. A town or city is usually the commercial and distributing center of a large area tributary to it. Philadelphia is the local center of an area having a radius of at least fifty miles; that is, more or less of the traffic within

FIG. 11.

that area centers in the city, its intensity increasing as the center is approached, and all this traffic wants to reach its destination by the most direct routes; other towns within that radius are secondary centers having, or needing, direct routes connecting them with each other and with the chief center; these routes began to be established as soon as the first settlements were made and increased in number and importance as the settlements prospered; they were natural routes; at first forest trails, then wagon roads, then post roads and turn pikes, and now carrying fast motor traffic and high speed electric lines, yet many of them are no wider and very little better than when they were first laid out.

These old roads which grew up in the early days to meet the needs of travel formed fairly direct lines from one village to another and connected all with an important trade center. There are at least ten such roads radiating from Philadelphia, not counting those upon the New Jersey side of the Delaware river, which occupy strategic locations and have from their very beginning been traffic highways of the first class; this fact should long ago have suggested the desirability of increasing their width in order that they might better fulfill their functions in the future.

FIG. 12.

There is no indication of any falling off in the percentage of increase of population in the more progressive industrial and commercial communities, and the doubling of the population in such cities as New York, Chicago, Philadelphia and Boston within the next thirty or forty years means that wiser provision must be made for caring for the general increase of traffic such an increase of population will bring, for this new population will spread over large areas which are now suburban or rural and will no doubt greatly influence the growth of nearby towns.

To provide properly for the transportation, both public and private, necessary for the service of the great urban populations of the

future, existing main traffic routes should be protected and measures for increasing their capacity as the need arises should be adopted; direct routes between important centers of population and industry should be established where none now exist and all of these should be planned with generous widths and easy grades.

Classification and standardization have been suggested by some progressive planners as an aid in simplifying the work of street planning and has met with some approval; the number of classes and standards proposed vary greatly, according to individual opinion or the seeming need of the city to which they are to be applied; those of Washington, a residential city, are quite simple and appear to be well adapted to a city of that particular class; they are—

Main thoroughfares	160 feet.
Secondary thoroughfares	120 feet.
Local streets	60 to 90 feet.

These are widths between building lines. This is the simplest form that has been suggested, but it is scarcely adaptable to an industrial city; the widths are greater than would be economical where a city builds up closely with small houses, as in Philadelphia.

Many German cities have adopted standards which are so elastic that the term seems a misnomer; they are—

In first class cities,

Main thoroughfares	Over 95 feet.
Secondary thoroughfares	65 to 95 feet.
Local streets	40 to 65 feet.

In second class cities,

Main thoroughfares	Over 85 feet.
Secondary thoroughfares	50 to 85 feet.
Local streets	33 to 50 feet.

There are many streets of from 100 to 200 feet in width in the big cities of Germany, the people of which live almost entirely in apartments or tenements, and this method of living makes wide streets almost necessary from the viewpoint of both economy and hygiene. Efforts are now being made in many of these German cities to es-

tablish the system of one family house, and this is having an influence on street widths.

The London Traffic Commission recommended five classes of streets for that city—

Main avenues	140 feet.
First class arterial streets	100 feet.
Second class streets	80 feet.
Third class streets	60 feet.
Fourth class streets	40 or 50 feet.

If a classification is to be of any great benefit the number of classes and the number of clear widths in each class should be reduced to the least possible, and for the purpose of this paper the following are suggested—

Main traffic streets	110 or 150 feet.
Secondary traffic streets	88 feet.
Residential streets	52 or 64 feet.

These seemingly irregular widths are based on suggested standard units of width for lines of vehicles, pedestrians, and planting spaces, the scheme of which will be explained further on; they are between building lines and should be subdivided in such manner as to give the least width of paving required for traffic, the remainder being made grass plot. Parkways, or streets intended to combine the uses of a traffic route and a parkway, should form another class and their widths should be subject to special study.

It is recommended that new or existing streets should not be opened or widened to these widths until they are reasonably necessary for safe or convenient travel, but the widths should be legally established and protected from the encroachments of buildings or other permanent improvements which might prevent their future development to meet increasing needs. This can be done, and has been done, in Philadelphia under an Act of Assembly for many years in protecting the general system of streets, and similar authority should be given to rural districts. Such a restriction may seem at first glance to be a hardship and an encumbrance on the property, but it is doubtful whether there has been an instance of real pecuniary loss due to it during the many years it had been in force.

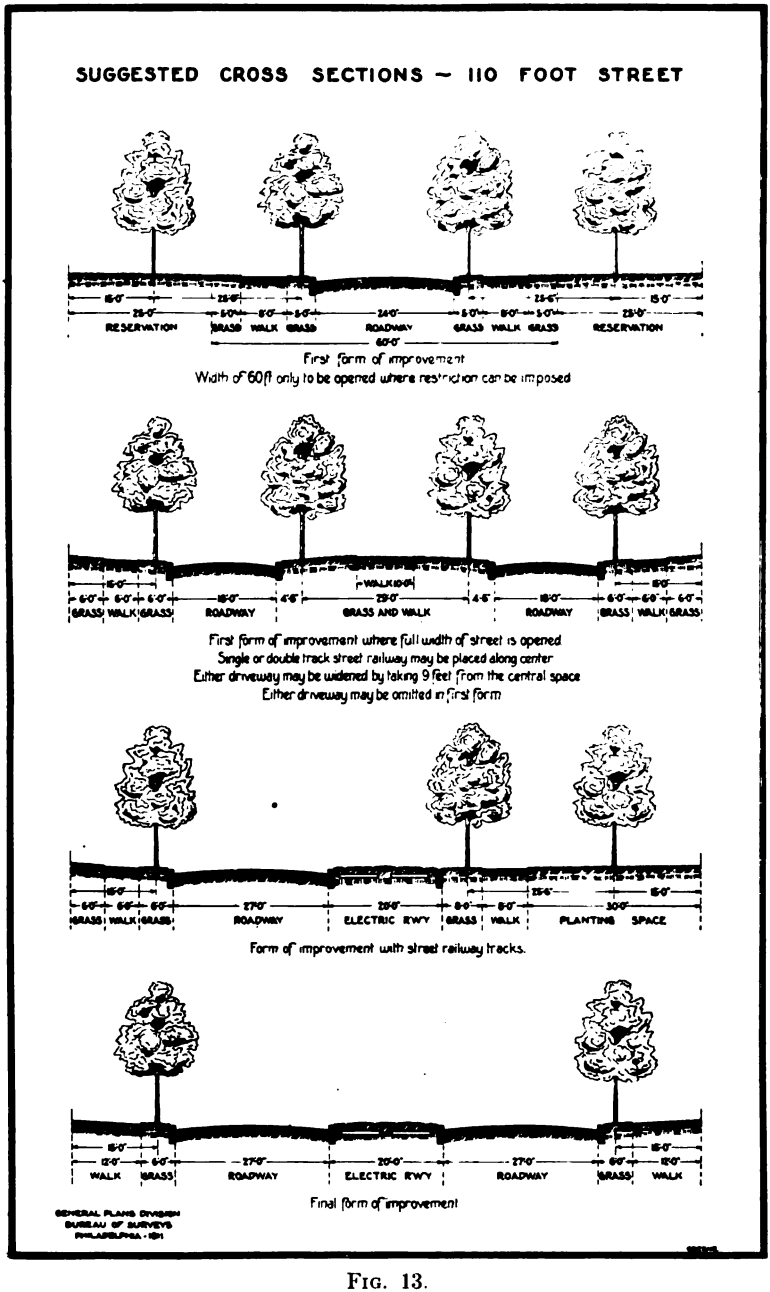

SUGGESTED CROSS SECTIONS — 110 FOOT STREET
RESERVATION
GRASS
WALK
GRASS
ROADWAY
GRASS
WALK
GRASS
RESERVATION
First form of improvement
Width of 60ft only to be opened where restriction can be imposed
GRASS
WALK
GRASS
ROADWAY
GRASS AND WALK
ROADWAY
GRASS
WALK
GRASS
First form of improvement where full width of street is opened
Single or double track street railway may be placed along center
Either driveway may be widened by taking 9 feet from the central space
Either driveway may be omitted in first form
GRASS
WALK
GRASS
ROADWAY
ELECTRIC RWY
GRASS
WALK
PLANTING SPACE
Form of improvement with street railway tracks.
WALK
GRASS
ROADWAY
ELECTRIC RWY
ROADWAY
GRASS
WALK
Final form of improvement
GENERAL PLANS DIVISION
BUREAU OF SURVEYS
PHILADELPHIA - 1911

FIG. 13.

No great hardship or depreciation of values could result along existing important highways if new buildings were required to recede 55 or 75 feet on either side of the centre line, and it would seem a wise policy for real estate operators and town site promoters to voluntarily place such a restriction upon their properties; as a matter of fact, property owners can, and frequently do, place such restrictions in rural and suburban sections more effectively than can be done by the public authorities. The general provision and recognition by property owners and the public authorities that certain roads are to permanently remain the great traffic routes and will not be abandoned in favor of some new route that may be opened more cheaply and made more popular should have the effect of establishing more stable values upon them, and the extra area thrown into them could be compensated for by making the purely residential streets somewhat narrower, for in many land development schemes roads which can never have any large usefulness for public travel are made wider than is necessary in view of the more open form of improvement which is increasing in popularity with both builders and home buyers.

With the increasing demand for rapid transit, underground railroads for both passengers and freight could be placed under these wide avenues or elevated lines could be erected along them and concealed by trees as is done in Paris and Berlin; they would also be most available for the main trunks of underground systems for many kinds of service, the numbers and character of which are constantly increasing. It is quite probable that the future will witness a great development of underground transportation and that much of the material now carried on the surface will be delivered by underground railways or through pneumatic tubes or similar devices. If the tendency toward the more open development of property continues it is doubtful whether the general system of underground galleries favored by some engineers will be financially practicable, and, if not, wide avenues will be necessary to accommodate their trunk lines. It is not beyond the realm of possibility that more space will be required in the future for sub-surface than for surface transportation along main arteries and with wide spaces between the building lines many of the underground structures could be placed beneath side-walks and grass plots and the necessity for the frequent tearing up of roadway paving avoided.

If restrictions can be enforced requiring buildings to recede to

established widths, the full width of the street need not be opened and improved until required for traffic; this, in the case of streets of any width or class, might not be required for many years after the original opening; take the street 110 feet wide for instance; its initial opening might be only 60 feet with a 24 foot driveway, a row of trees and a sidewalk on each side; this is equivalent to the width of almost any of our best-improved and most-traveled country roads; if restrictions cannot be imposed and the initial opening must be to the full width the first roadway might be placed in any one of several locations, in the centre or on either side, or it might even be allowed to meander somewhat in very wide avenues and the walks might do the same, but this should only be permitted in rural or suburban sections where there is not likely to be any early necessity for full width development; if trees are planted they should be placed in locations where they will not be disturbed in the final improvement of the road; as the demands of traffic increase the roadway could be widened or new ones opened in accordance with a pre-determined cross-section. The principle of the elastic sub-division could be applied with advantage to all the various classes and widths of streets and if no further widening of driveways or walks was ever required after the initial opening, as would probably be the case in many instances, the streets would always remain very attractive, or afford opportunities for being made so.

The establishment of cross-section subdivisions might be simplified by adopting units of traffic width for determining each section. There is some difference of opinion among advocates of this method as to the proper width of units; some suggest 8 feet and some 9 feet as the unit width for a line of vehicles; motor trucks are coming into very general use and there is a tendency toward increased widths of both gear and body among some makers of them; the standard maximum at present seems to be 7 feet or 7 feet 3 inches and the extreme 9 feet 6 inches, over all; widths of over 7 feet are reported as being difficult to handle, bothersome in general traffic and subject to overloading. Two feet should be a normal unit for a line of pedestrians and the width for a grass plot with a row of trees should be a multiple of the unit for a line of pedestrians. Street railway and general traffic should be kept separated and prevented from obstructing each other as much as possible, and the former should be

given an independent right-of-way on wide streets; the unit of width for a double track surface line should be 20 feet.

These standard units used in combination with an intelligent forecast of the probable future needs of the street would afford a more rational and systematic means for determining proper and economic widths than the unreasoning and arbitrary methods usually employed. Minimum widths based upon them and upon the probable immediate use of the street could be used in the initial improvement of the driveways and footwalks and these widths could be increased by units as the travel increased.

Main traffic routes should be planned in as direct lines as possible between important points, but they need not necessarily be straight; sharp curves and sudden jogs should, however, be avoided and changes in direction should be accomplished by means of curves rather than angles; an easy curve or a well planned fork will tend to break the monotony of long, straight lines; topographical conditions should not be allowed to exert as large an influence as in streets of less importance; detours which would materially lengthen the route should only be made to avoid excessive grades; some heavy cutting and filling is to be preferred over many windings in a great traffic route which in the ordinary course of events may be called upon to carry the trade of a great city for centuries; the first plan of a street must usually be considered its permanent one, for its location, width and grade cannot be changed at will to accommodate increasing traffic, as is the case with a railroad line.

Secondary traffic streets should be established connecting the main traffic ones with each other and with secondary centers of population and industry, and these two classes of traffic streets should form the skeleton plan, designed with a view of creating direct routes at reasonable intervals throughout the entire city and surrounding districts without regard for the development of any particular property, but with an intelligent purpose of encouraging an equal distribution of opportunities for improvement.

As there are local business needs to be served in every community, or at various points in large and widespread ones, and as the social intermingling of the people in every legitimate manner should be encouraged, the planning of the traffic streets should take into consideration the points at which local business centers may be established, and also those which seem most available for the purposes of

civic or social centers. The municipal authorities cannot directly control the drift of business, but they can control the location of libraries, schools, public halls, gymnasiums, playgrounds and baths, branch offices of the central government, fire houses, police stations and other buildings necessary to the proper administration of the public business; these public buildings, properly grouped, form the civic or social center and by reason of being the center of the social, educational, and official life of the community will attract hotels, theaters and general business. These centers should be planned in such a manner that traffic may have an option of passing either through or around them so that congestion in them may be avoided. The village "green," characteristic of all New England towns, is the embryonic type of what such a center should be. It is a somewhat sad commentary upon the wisdom and skill of some of the more modern town planners to say that the men who laid out the American towns of a century or two ago were wiser than they in their appreciation of the value of civic centers and open spaces for the use of the people, that those town planners of the long ago established a custom which, after having been abandoned for more than a century, has become one of the vital issues of the new town planning, and that the restoration of the park and the open public place is due to the active interest of private citizens and associations in civic affairs.

Parks, playgrounds, and other open spaces for the use and enjoyment of the people have come to be recognized as essential features of modern urban improvements and should be provided for on every plan of street extension. The selection and distribution of such places can be more intelligently made in connection with the establishment of traffic streets than if left until residential or other development has commenced and the value of land has advanced.

With an efficient system of traffic streets firmly established, other parts of the plan, covering residential streets and those which can never be of much importance to through travel, should be left as elastic as possible in order that any legitimate form of development may be accommodated. Industrial sections, high class residential sections, and sections given to the modest type of dwellings, each require a different treatment of the street plan. In factory districts the streets surrounding industrial plants should be wide and straight while those in the same vicinity upon which the homes of the workmen front may be of a quite different type; some of the garden

cities and industrial colonies of England and Germany suggest admirable arrangements for this form of development, the driveways and walks being narrow and the building set back with foreyards or arranged around open spaces or squares.

High class residential sections lend themselves to most attractive forms of planning; houses built singly or in pairs on large plots permit greater freedom in establishing beautiful streets and narrower paved areas are allowable; the local travel through a residential section may even be accommodated by lanes wide enough for two vehicles to pass and a single footwalk.

In sections given to more modest dwellings built in pairs or long, solid rows on small plots, a minimum width between building lines should be established, and this width should be sufficient to allow a part of it to be planted; in such a section the streets will naturally be closer together and economy will be effected if the paved spaces be only such as are necessary to the local use.

The question of grades is one of great importance and should receive the most careful study; grades that are steep or irregular or that break at frequent intervals are neither desirable for traffic or attractive in appearance; long, even slopes should be obtained wherever possible, especially on straight streets; upon traffic streets the maximum should not exceed one in twenty unless physical conditions render it absolutely impossible to keep within it, and places where it is adopted should be short, few and far between. Maximum grades in Europe, even in hilly cities, are generally lighter than in America, and in some instances are kept within the limit by rampeing or zigzagging the lines. In some parts of Germany, the law limits the grade to one in fifty; in France the maximum on national highways is one in thirty-three and on departmental highways one in twenty.

Heavy grades are as difficult and dangerous in their descent as in their ascent; this is well illustrated in the one in ten grade on Market and Chestnut streets, Philadelphia, approaching Delaware avenue, where heavily laden vehicles zigzag across the street in ascending and do the same or drag the wheels along the curb as a brake in descending.

Under the methods which have heretofore prevailed in municipal street planning, considerations of attractiveness have been almost entirely neglected and whatever beauty our streets possess is due to private initiative; the street has been regarded as just so much

space to be paved between houses, the idea apparently being that the municipality could not afford to construct or maintain anything there except paving and such unlovely objects as telegraph, telephone, and trolley poles; we shall probably find in the future that considerable of this area can be used for grass plots and trees, that the cost of maintaining them properly need not be prohibitive, and that the attractiveness of the streets will be immeasurably enhanced; it will be interesting to note whether this change, which is certain to come, will result from intelligent and well-directed efforts on the part of the public authorities or allowed to go by default until it is forced by political or private agitation.

Competition is as keen among cities as it is among individuals and skilful advertising is as necessary in establishing and maintaining a city in a position of eminence as it is in assuring success in business; the most effective advertising of the city is accomplished through the agency of the street and its furnishing and the opportunity and encouragement it gives for expressing the civic pride and ambition of the individual and the community; a city whose streets are uniformly commonplace and monotonous will never inspire its citizens with a very high order of civic pride or patriotism, nor will it engage the earnest attention, admiration, or respect of the visitor. One reason why Philadelphia is not more favorably advertised and more widely commended is because she has so little of the dignity, beauty, and charm that arms her citizens best in defence against criticism and that attracts the interest and applause of the tourist and the casual visitor; if we are to achieve and maintain any position of distinction as a world-interesting city we must cultivate a larger appreciation of civic art and apply it more industriously in connection with the doing of such big and progressive things as are making other American cities famous, helping to attract the world to Europe and turning a strong tide of world-travel toward the ambitious cities of South America.

There are two classes of streets in foreign cities that are the delight of tourists; one is the narrow thoroughfare of the olden time, full of angles and offsets, curious gables, picturesque open spaces and quaint buildings; the other is the wise, dignified, tree lined avenue or recent years, flanked by stately buildings bearing the finished touch of the most skilled architects. Our American cities offer little in either of these classes; the picturesque passageways of the Middle

Ages will never be reproduced and we seem unable or unwilling to properly develop the grand avenue of modern times; the wide streets we have are either a waste of desolate paving or the attempt to rescue them from that condition, which has resulted in grotesque combinations of various schemes devised and carried out with the best intent by individual property owners but without proper advice, control, or supervision, and only occasionally do we find a street or a neighborhood where all the surroundings give expression to a well-ordered and harmonious conception.

American cities lead the world in the beauty and charm of their suburbs, but as urban improvements are pushed outward much of this is destroyed by inflexible insistence upon some formal scheme of development, regardless of the character of the street or the nature of the adjacent territory. With all our boasted wealth and progress, our great municipalities have failed dismally in both the efficiency and attractiveness of our streets and roads; the best we have to show, with few exceptions, is in our smaller towns or where the development has been due to broad-gauge private enterprise.

No plan of a city has been well or wisely conceived unless the citizen can find pleasure and enjoyment in his surroundings as he traverses its streets; no plan is complete unless it offers the pedestrian something to repay him for his wanderings and some enticing place where he may halt to rest, whether it be in some quiet side street in contemplation of a garden, a fountain, or a statue, or in the midst of the rush and roar of traffic in contemplation of man's strenuous struggles in the world of trade; no street is well planned unless it expresses an intelligent conception of the uses to which it and the property bordering upon it may be put, and invites and encourages those legitimate uses in their best estate.

DISCUSSION

MR. S. M. SWAAB.—I noticed in the pictures of some sections of suburban property around Philadelphia half a dozen telegraph poles. Do they have them abroad?

A.—In most cases the wires are carried over the buildings and poles are erected in the yards or attached to the buildings.

MR. SWAAB.—In the case of the elevated railroad in Berlin were the trees planted to hide the structure or were they there before?

CHAIRMAN.—I happen to know that section; the trees were planted to hide it.

MR. SWAAB.—If you had some pictures of the Berlin elevated, you could show one of the handsomest elevated railway structures in the world.

MR. HALDEMAN.—Well, I was not particularly impressed with the design of the metal structure.

CHAIRMAN.—They have endeavored to make this elevated structure as nearly noiseless as possible.

MR. HALDEMAN.—It is very nearly noiseless. Not only are the elevated roads of Berlin operated very silently, but all the surface roads in the German cities are so operated. I do not think you will hear bolts, chains or other loose parts rattling on their cars, there are no flat wheels or anything of that kind.

MR. WEBSTER.—Mr. Haldeman has given a very clear demonstration of the difficulties encountered in proper street planning; also in the planning of a large city. Laying out a new town in virgin country represents a problem which is very difficult to solve and requires the best skill of the Town Planner. It is almost impossible for any one to determine—I might say it is almost impossible for any one to make an intelligent guess—as to how such a town in its long years of development is going to grow. Consideration must be given as to conditions which may develop which will change the attitude of the local government, the advent of one or two lines of steam or electric railroads may change what was planned originally to be a residential section into a manufacturing district, and in the laying out of streets it must be realized that those to be used for business and transportation purposes must necessarily be wider than those in residential sections. In fact, in planning a small town, to lay out wide streets in a residential district would not only be undesirable, but would place an unnecessary cost for street improvements upon owners of the land. In Philadelphia, who, twenty-five years ago could have forseen the great concentration of people which occurs daily in the vicinity of Broad and Market Streets, which is due largely to the advent of the department store and the large office building, which accomodate thousands of people? This has placed upon the city new obligations which were neither anticipated nor provided for.

In the growth of our cities it is necessary not only to provide for the accommodation of the people upon the surface of the street, but it is also necessary to make provision for those underground structures which are so essential to their comfort and convenience. To supply those necessaries of life which modern civilization demands, all kinds of sub-surface structures are required; the sewer and water pipe were probably the only ones anticipated one hundred years ago, but now provision must be made for conduits to carry telephone and telegraph wires, pipes for gas, pneumatic tubes and other similar structures which in the future will increase in numbers and size. On the principal streets in the business center of the large city the demands of transportation require that subways be constructed in order that the people may have a quick and economical conveyance between their homes and places of business. These demands both on the surface of the street and underground are such that in the older cities they can only be met by laying out new streets or the widening of existing thoroughfares.

In the planning of cities it is now considered essential that civic and trade centers be established and that direct avenues of communication be laid out from these centers and the residential districts to various places of business, thus providing not only for the distribution of the population, but for direct avenues of communication.

Many of our large cities were formed by the consolidation of numerous small towns that had grown up in close proximity to each other—of which Boston and Philadelphia are good examples—it is difficult to anticipate in planning the conditions which arise by such consolidation. It would therefore seem wise to have a metropolitan authority covering not only the city, but the immediate suburbs, fully empowered to plan for the development of the entire section. By this means a comprehensive plan could be adopted which would be worked out to fit in with the growth of the towns, and at the same time, result in a harmonious and economical development of the greater city.

In the improvement of streets in advance of their ultimate requirements, it is advisable to adopt in this country, as has been done abroad, what is known as the elastic street, which provides for laying out the street upon the plan of the full width for its future needs and of improving the roadway of a much narrower width, leaving the space on either side for grass plots. In this way the first cost of the street improvements is kept within reasonable limits and ample provision is made for the future.

MR. H. H. QUIMBY.—Mr. Webster mentions the crowding on Broad Street and on Market Street, but he failed to mention the crux of those influences; I think that is probably the City Hall. Mr. Haldeman in showing the picture of some important city said, I think, that that city hall had a proper setting, and it appeared to have so large a park around it that people who came to that city hall would have to walk a considerable distance. Suppose our own City Hall were surrounded by a large park, then everybody who goes to the City Hall would have to walk, say from the nearest store, perhaps a distance of from 500 to 1,000 feet. I think they would be apt to regard that park as not very desirable. The City Hall is a place of business, whatever people seem to think of the City Hall as a place of work; people go there on business and not to loiter. The crowding of business around the City Hall indicates that the City Hall is the centre of business activity, and it seems to me that the utilization of a large area around such a building is overdoing a good thing. People who are devoting their whole attention to city planning, and propose introducing foliage into cities, are perhaps apt to overdo it.

MR. HALDEMAN.—It is not a question of overdoing it, it is a question of doing it right. If it is done right, it will not be overdone.

It is not suggested that the City Hall of Philadelphia should have an open space around it exactly like that surrounding the City Hall in Salt Lake City. It should have a space appropriate to its mass and architecture. That is the great principle of town planning, to have these things in proper proportion. It is very true that the City Hall is a place of work, as is the entire central section of the city. Financial, legal, corporation, and certain other kinds of business will probably always be conducted chiefly in the central district of the city,

but there is no reason why all the large department stores and other high class stores should be there. One of the principal objects of city planning is to discourage the creation of one congested center and to encourage the growth of business centers in various parts of the city. All large cities are beginning to realize the evils of concentration and of crowding all business into one center.

MR. W. C. FURBER.—In the course of Mr. Haldeman's very excellent address on Town Planning, he made one statement in regard to the tendency of town development toward open spaces and toward separate dwellings. I have been attending the sessions of the National Housing Convention in Philadelphia during the past week, and I have been surprised and amused at some of the expressions of opinion regarding the Philadelphia method of laying out streets, which, in my opinion, are largely due to ignorance. I thought our wide streets and detached houses were pretty nearly the right thing, but in these various conferences where these subjects came up, the expressions of opinion were anything but favorable toward the Philadelphia methods. One speaker said that some of our Philadelphia detached houses were put up in Newark, N. J., and they had been unable to rent them; that the Newark people preferred the two-decker flat, on the theory, I suppose, that the builder could rent the upper part and live in the lower part himself, leaving the upper one to take care of his overhead charges. It was also stated that in New Rochelle people are giving up private houses and living in flats. The speaker was now living in a flat by choice. In analyzing these methods, he emphasized the difficulty of securing cooks and servants, and he thought that in future, skeletons of cooks and servants would be preserved in the museums. He also referred to the difficulty of getting houses provided with hot water, and conveniences for the removal of ashes, etc., and he thought the progress of modern development was in favor of doing these things in a communal way, which would be better than in an individual way, which, of course, has the merit of truth.

The best possible way towards the development of the individual house in the way of a combination of general utilities, is in the Girard Estate, at 17th and Shunk Streets; we all know that is a popular development in Philadelphia.

Mr. Haldeman spoke of the unfortunate development of cities in the ways they were not expected to go, and I never ride out to Willow Grove but it makes me feel sad to see the pushing of the two-story or three-story operation house out into that beautiful country. I think it is this side of Logan that there is a development of two-story houses that jar your sense of the fitness of things, as you compare them with the beautiful landscape with which they are surrounded. It may be otherwise some day, but it is inevitable as long as you have the private ownership of land and where the sole object is the greed of the owners.

MR. S. M. SWAAB.—I am not very much of a political economist, but I would like to ask my friend Mr. Haldeman whether those European methods of laying out streets is not really a matter of economy more than anything else?

What impressed me particularly in the pictures that Mr. Haldeman showed was the vast quantity of foliage and trees in the continental cities, and the considerable distances between the buildings. It seems to me that owing to the

distance between the individual houses the water and gas pipes, sewers, etc., will have to be so much longer, and will, therefore, cost so much more money per inhabitant than they do in American cities where the houses are built close together, and this is probably why the European citizens are taxed more than we are here. Mr. Haldeman also said that I called his attention to the artistic value of the elevated railroad structure in Berlin. In my judgment they have produced a standard which in that respect at least is superior to anything I know of. He said that the elevated railroad in that city was considered a very noiseless structure, and placed the emphasis more on that than anything else. After the Market Street elevated structure was put in service the several European railroad engineers who saw it agreed that it was the most noiseless structure of any elevated railroad that existed at the time it was built, and I think that was said by Mr. J. B. F. Davies, of New York, when he was here a couple of years ago in a talk on elevated railroads and subways.

CHAIRMAN.—A number of thing have been touched upon here. Mr. Haldeman showed a few of the very wide streets in Berlin—one in particular, called Hierstrasse (Army Street). The originator of that street was the present Emperor, who wanted to have the means of getting large bodies of men from Berlin to Potsdam. An existing street was widened by tearing down all buildings on one side, which is why on one side of the street you see a very modern type of architecture and on the other an older stereotyped form. The street itself is undeniably beautiful, but its cost was enormous. On the other hand, the cost was again brought in by the erection of these new structures, which, while they look rather palatial, are only flats. That brings in something that Mr. Furber touched upon. While these houses are simply flats for workingmen and small tradespeople, they are exceedingly well built. They are fireproof structures, and there is not a room in them that has not direct light. They have wide stairways and wide entrances into courtyards. The building authorities demand that these courts have a width in proportion to the height of the building, and that every room have direct daylight. That results in these structures all being large ones. A man cannot put up a small building and leave so much space unoccupied, so he perforce puts up a large one, surrounding the court.

Mr. Swaab questioned the economy of such buildings, believing that these requirements must carry with them enormous costs. The cost per occupant is low; though the first cost of the work be high. The cost per occupant is lower than under our Philadelphia plan.

In our Philadelphia individual house plan uniformity is horizontal. If you go to a German house and drop a shot down from the same spot in each roof, you will strike a similar table on each floor all the way down to the cellar, shoot horizontally around the square of a Philadelphia "operation" and you hit the same picture in each house. The German lives vertically, the Philadelphian horizontally, and both to monotonous sameness in the mass.

Referring to the Hierstrasse, the municipality of Charlottenburg would not have its section called that, but called it Bismarckstrasse, much to the discomfiture of the Emperor, who is accused of an overfondness for Bismarck.

There is one thing they have which would be very desirable in Philadelphia

also. On narrow streets no new buildings can be put up to the old line, but must be set back to a new line, thus insuring a wide street after a while.

MR. SWAAB.—We have the same thing in Philadelphia. We have it on every street, Arch Street, Walnut Street, and other main streets.

CHAIRMAN.—Mr. Haldeman referred to the desirability of a park setting for our City Hall, to which some exception was taken as placing the City Hall more remote. It is not necessary to occupy great width to secure park effect. Many European cities have such settings for large public buildings, but the space occupied to make these surroundings is not actually large enough to cause anyone to become leg-weary. But the treatment does demand skill. Speaking of our own City Hall, I think it would do no harm at all if we had a few trees to hide it.

Much mention was made of the fact that our Philadelphia business is concentrated. That is not a necessary characteristic of a large city; but is a village practice. The business of our town while small was concentrated around the City Hall a long time ago; and a great many people, not Philadelphians, and a few who are, hold it a reproach that it should still be so. It is a small town view still largely held by a great many; take, for instance, this Club, this meeting would be much better attended if it were within one and a half or two blocks of the City Hall, instead of four. We have not yet caught up with our growth.

The real cause of the high cost of living in European cities is Europe's militarism, not only does it cost a good deal to maintain a soldier or a sailor, but this taking a man out of industrial life and putting him in the army or the navy deprives the community of a self supporting and a contributing member and adds an eating member whom the others must support; and in that you have basic cause for the high taxation prevailing in Europe. We here save that, but are like the woman who, saving a dollar, feels rich enough to spend two, and does.

MR. HALDEMAN.—In reference to the economy of the wide streets of Continental cities, I will say that the individual street does cost more than ours, but the percentage of street area is much less than in our big American cities. Nearly one-half the area of Manhattan Island is occupied by streets; in Philadelphia the street area varies from 30% to 50%; in Berlin it does not exceed 20% to 25%.

MR. FURBER.—The character of a street is determined by the character of the buildings upon it. You pointed out the superiority of the large flat house. With proper facilities for living in, that is quite an institution. I think we believe that that type of building is infinitely to be preferred to our cheap, two-story house that we are familiar with in Philadelphia, and as you have also pointed out, that the unit cost per square foot of street serves up a reason for this increased density of population, which makes it easier to compare with our development.

CHAIRMAN.—People who live in those flat houses must suffer a certain amount of regulation, which I do not think we would submit to in Philadelphia. If

those flat houses were lived in under the same conditions as our houses are lived in, they would soon become infernal nuisances and disease traps that you could not stand. Therefore, I do not think those houses are practicable in a community like ours. Our populace has not yet arrived at the stage of communal civilization that acknowledges the community a right to interfere in what each individual considers his or her personal right to endanger their neighbors.

MR. FURBER.—Up until recently Philadelphia has fought against apartment houses, and now we see people are taking to them with great avidity. A section of Germantown is being invaded that way.

CHAIRMAN.—Yes, but those are of a different character. The German low-priced flats have street fronts of a hundred feet or more. As the streets are very far apart there are four or five sets of flat buildings of five stories each in series separated by courtyards and planting spaces. Additional flats with a wide driveway from the street to the courts. Then the flats range from three to ten rooms. And practically every family lives up to the Rooseveltian ideal. Can you imagine that kind of rabbit warren in Philadelphia? Why, if a policeman got into such a house here, he would be in peril of his life; the women would mob him. So, desirable as these may be under proper regulation, you have to reckon with your conditions.

MR. E. M. NICHOLS.—Is it not a fact that our housing conditions are better than theirs?

CHAIRMAN.—Almost the worst housing conditions in the world are to be found in our theoretically free and civilized United States, and especially in New York City.

MR. NICHOLS.—Is it not a fact that the people who come here from Europe are used to that?

CHAIRMAN.—No, they are not willing to live like that, nor are they used to it. They have to put up with what they can get.

MR. W. C. FURBER.—Strange as it may seem, some of our worst slums are out in our suburbs, Bryn Mawr and the Main Line section, where one would not expect to find them.

MR. NICHOLS.—I do not care where they are; who is responsible for it?

CHAIRMAN.—The responsibility for our worst housing problems rests with ourselves, with the low or almost absent sense of civic responsibility of those who cannot help themselves—an absent sense which permits exploitation by real estate dealers and house owners looking only to their direct returns, and without glasses corrected for shortsightedness. Not that our owners are any more rapacious or shortsighted than others the world over; they are not. It is even certain that many, of their own accord, do much to improve conditions, more than European individuals do. But relying on individual communal sense to protect the community against individual greed is like resting on a broken reed. Finally, the responsibility does and must rest with the community, and conditions will become better only with our advance in communal civilization.

PAPER NO. 1122.

THE MANUFACTURE OF PETROLEUM PRODUCTS

By Dr. F. C. ROBINSON

Chief Chemist of the Atlantic Refining Co.

Read December 21, 1912

It is a real privilege to address you, a body of engineers, on the present subject—The Manufacture of Petroleum Products—because all of these products are or might be used in some engineering operation. I have frequently had occasion to inform my friends that the oil refinery does not manufacture dyes, acetanilid and allied products, nor perfumes. We do not make perfumes.

The first group of products from petroleum is made up of Gasolines and Naphthas. There is some confusion among the various names, benzine, gasoline, naphtha, etc., but the best practice is to use the word gasoline for any mixture of light hydrocarbons intended for use in any kind of vaporizer, *i. e.*, to be gasified in a gas machine, gasoline torch, gasoline stove or automobile carbureter. Also to confine the word naphtha to mixtures of hydrocarbons intended for some purpose that requires a very good odor, such as the naphtha used by cleaners, varnish makers, soap makers, etc. In this scheme, the word benzine finds no place. Gasolines and Naphthas vary in average boiling point according to the use for which they are intended, but all lay between 125° F. and 280° F. In all cases it is essential that they be free from all heavy hydrocarbons that do not evaporate from the hand.

The next group consists of several grades of Lamp Oil. Lamp Oil is a mixture of hydrocarbons whose average boiling point is about 450° F., entirely freed on the one hand from gasoline or naphtha and on the other hand from the heavy hydrocarbons that belong to Gas Oil and Lubricating Oil and that would make the oil act badly in the lamp.

The next class is gas oil. While oils of all degrees of volatility have been used, the most economical for the gas maker consists of

a mixture of heavy hydro-carbons with an average boiling point of 600° to 650° F. It must be practically free from Gasoline and Lamp Oil on the one hand and from the heavy lubricating Oils and Asphalt on the other.

The next group is Fuel Oil. This oil occupies a peculiar position. It must be oil and must not contain gasoline and must be of such a consistency that it can be pumped through pipes and burners, but except for these restrictions one oil is practically as good as another for fuel. The light oils have a slightly higher heat of combustion per pound, but the heavier oils have a slightly higher heat of combustion per gallon. For some purposes, such as oil engines, special oils are required, but, in general, Fuel Oil is made up of oils that cannot be used for any better purpose.

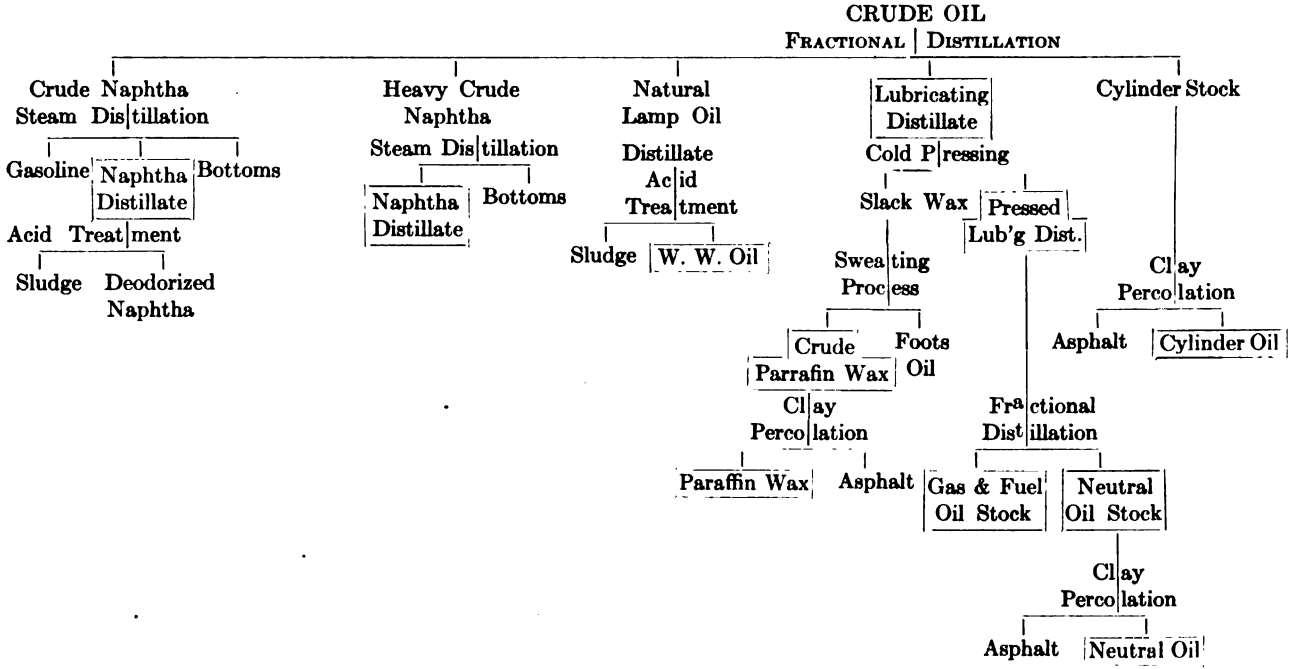
The next group is that of Spindle Oils—Neutral and Paraffin Oils. This important group includes hundreds of light lubricating oils designed for use on thousands of different light machines, including Gas Engines. They must be free from gasoline and lamp oil in order that their flash test shall be high enough to prevent loss by evaporation. The important point to that is that they shall have the proper viscosity for the use intended.

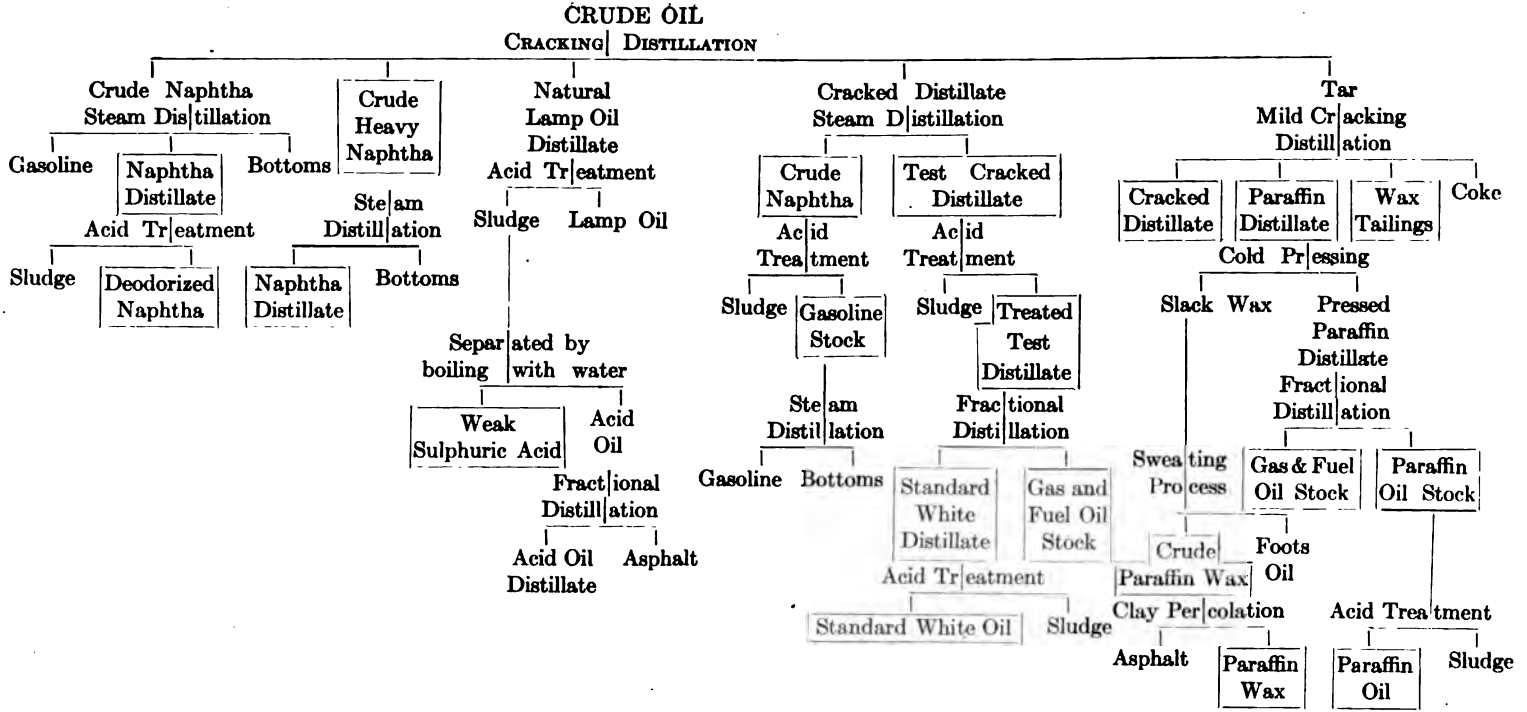
The next group is that of Steam Cylinder Oils, which consist of the heaviest hydrocarbons contained in certain crude oils. In this case also the flash must be such that the oils will not evaporate in a steam cylinder and must have the proper viscosity for the use intended at the temperature of the cylinder.

The next group—Paraffin Wax—consists of a mixture of hydrocarbons of the Paraffin series about $C_{23}H_{48}$ to $C_{35}H_{72}$. The commercial article is rated according to the melting point, which varies from 100° to 135° F.

The next group—Vaseline or Petrolatum—consists of the higher members of the Paraffin series which settle from crude oil mixed and inseparable from some of the oily constituents of the crude. It is marketed as the light colored material used in medicine and for toilet purposes or as the dark colored sticky material used in large quantities by the makers of oiled paper

The next group—The Dust Laying Oils—consists of Petroleum Asphalt in solution in oils similar to gas oil. The basic idea in their manufacture is that the solvent will slowly evaporate, leaving the dust particles covered wih a sticky adherent film. These oils have proven successfu' as a cheap means of laying dust.


CRUDE OIL
FRACTIONAL DISTILLATION
Crude Naphtha Steam Distillation
Gasoline
Naphtha Distillate
Bottoms
Acid Treatment
Sludge
Deodorized Naphtha
Heavy Crude Naphtha Steam Distillation
Naphtha Distillate
Bottoms
Natural Lamp Oil Distillate
Acid Treatment
Sludge
W. W. Oil
Lubricating Distillate
Cold Pressing
Slack Wax
Pressed Lub'g Dist.
Sweating Process
Crude Parrafin Wax
Foots Oil
Clay Percolation
Paraffin Wax
Asphalt
Fractional Distillation
Gas & Fuel Oil Stock
Neutral Oil Stock
Clay Percolation
Asphalt
Neutral Oil
Cylinder Stock
Clay Percolation
Asphalt
Cylinder Oil


CRUDE OIL
CRACKING
DISTILLATION
Crude Naphtha Steam Distillation
Gasoline
Naphtha Distillate
Bottoms
Acid Treatment
Sludge
Deodorized Naphtha
Crude Heavy Naphtha
Steam Distillation
Naphtha Distillate
Bottoms
Natural Lamp Oil Distillate
Acid Treatment
Sludge
Lamp Oil
Separated by boiling with water
Weak Sulphuric Acid
Acid Oil
Fractional Distillation
Acid Oil Distillate
Asphalt
Cracked Distillate Steam Distillation
Crude Naphtha
Acid Treatment
Sludge
Gasoline Stock
Steam Distillation
Gasoline
Bottoms
Test Cracked Distillate
Acid Treatment
Sludge
Treated Test Distillate
Fractional Distillation
Standard White Distillate
Gas and Fuel Oil Stock
Acid Treatment
Standard White Oil
Sludge
Tar
Mild Cracking Distillation
Cracked Distillate
Paraffin Distillate
Wax Tailings
Coke
Cold Pressing
Slack Wax
Pressed Paraffin Distillate
Fractional Distillation
Sweating Process
Gas & Fuel Oil Stock
Paraffin Oil Stock
Crude Paraffin Wax
Foots Oil
Clay Percolation
Asphalt
Paraffin Wax
Acid Treatment
Paraffin Oil
Sludge

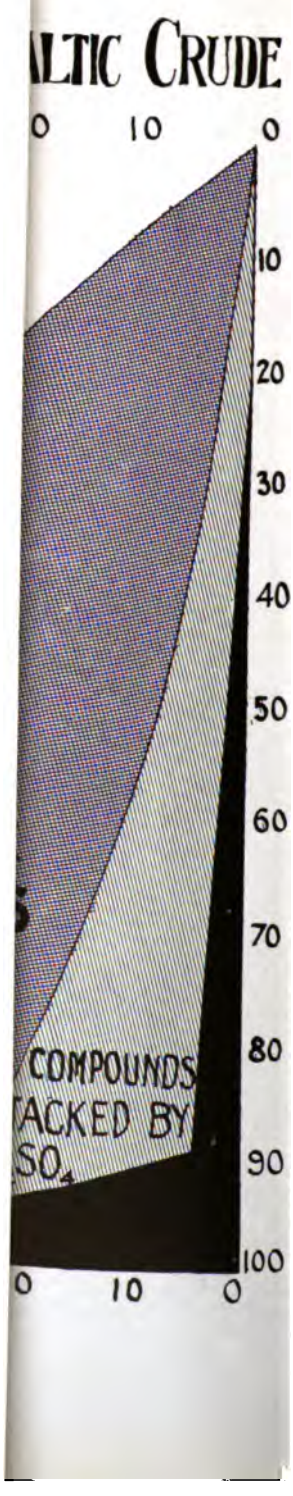
The next group—The Road Binders—consists of petroleum asphalt properly fluxed with heavy Petroleum Oils that will not evaporate and of such qualities that they will bind the road materials together both in summer and winter.

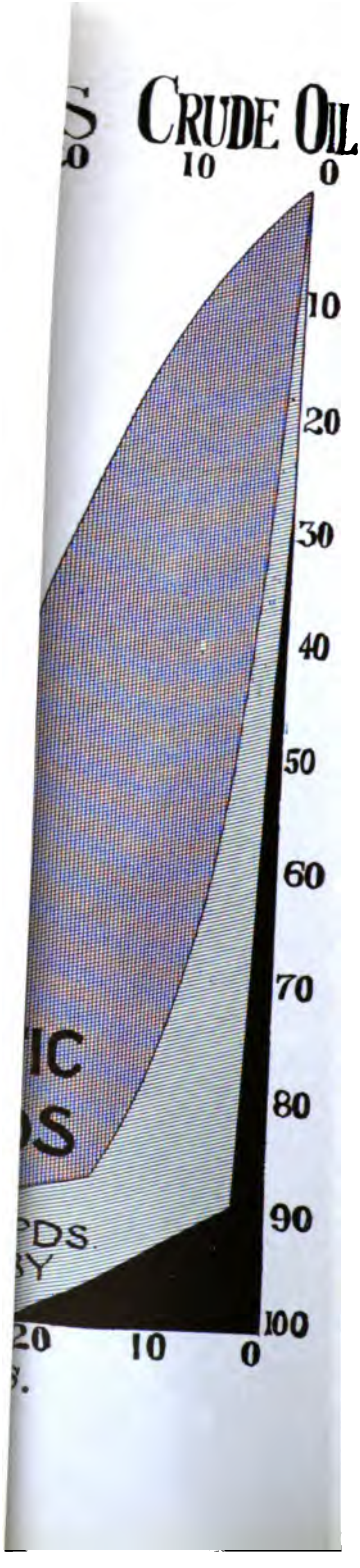
The next group—Coke—contains but one member. This material being almost entirely free from ash, is used very extensively by makers of Electric Carbons.

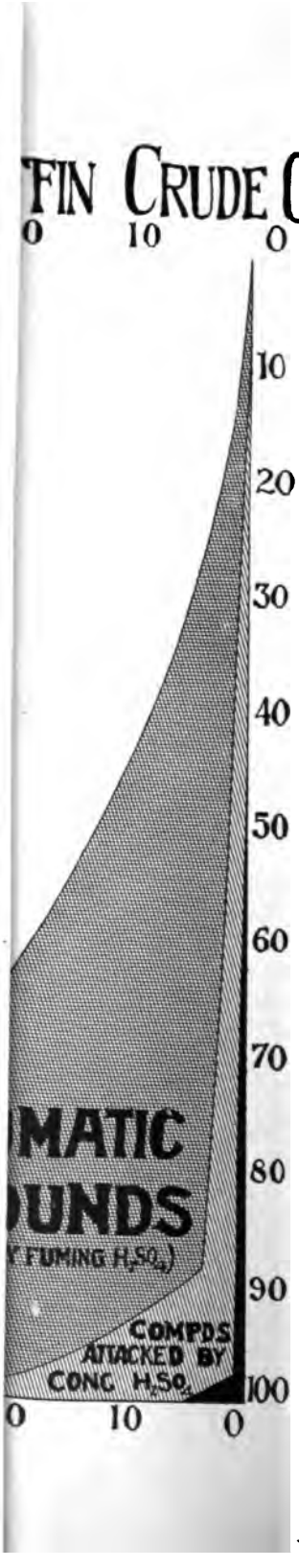
1. These are the desired products. Now let us look at the Crude Oils from which they are obtained.

2. There are about as many varieties of crude oil as there are oil fields, but the refiner recognizes three distinct types, because each type must be handled by different methods. *Viz.* (1) The paraffin base crude similar to that found in Pennsylvania and West Virginia and being essentially light colored crudes containing paraffin. (2) Asphalt Base Crudes similar to those found in Texas and California and being essentially black and containing no paraffin. (3) Mixed Base Crudes similar to those found from Ohio to Oklahoma and being essentially mixtures of paraffin and Asphalt Base Crudes.

3. In order to obtain some idea of the chemical and physical nature of the crude oil let us imagine a sample of Mixed Base Crude brought into the laboratory for a thorough examination. The Chemist would probably distill the sample in a vacuum or in some similar manner in order to avoid destructive distillation and would save the various fractions separate. He would not distill off more than 90% because the heaviest 10% cannot be distilled without breaking it down into simpler molecules. He will then start to examine the various fractions and will keep a record similar to the middle chart. The horizontal lines indicate the 10 fractions. The first fraction will be a light mobile mixture of hydrocarbons whose average boiling point is about 227° F. The second is a slightly darker and slightly less mobile mixture of hydrocarbons whose average boiling point is about 295° F. The third cut again darker, heavier and less mobile, boiling point 369° F. The fourth cut still heavier and 460° F. boiling point. The fifth cut is about 530° F. boiling point. The remaining cuts are increasingly heavier, more viscous and darker in color and the residue in the still is a soft pitch. The chemist now asks what these ten fractions are chemically and he recognizes four groups of compounds in each fraction that the refiner may have to isolate or remove. First the coloring matter indicated in the diagram by the black area.


ALTIC CRUDE OIL
0 10 0
10
20
30
40
50
60
70
80
90
100
COMPOUNDS
TACKED BY
SO4
0 10 0


CRUDE OIL
10
0
10
20
30
40
50
60
70
80
90
100
20
10
0


FIN CRUDE OIL
0
10
0
10
20
30
40
50
60
70
80
90
100
MATIC
UNDS
FUMING H_2SO_4)
COMPDS
ATTACKED BY
CONC H_2SO_4
0
10
0

He can isolate this group by bone black or fuller's earth. When isolated in a pure state it is a jet black brittle compound which is very similar to the purest asphalt. A second important class of compounds is the material soluble in strong sulphuric acid. The low boiling members of this group represent the odor-bearing compounds of the crude, while the higher members are rich in sulphur, and are easily oxidized. The refiner frequently has to remove a portion of this class. A third group is that of aromatic hydrocarbons, benzol, naphthalene, anthracene, etc., which may be removed by agitating the oil with fuming sulphuric acid. The remainder of the crude oil unattacked by fuming sulphuric acid is made up of the naphthene and paraffin series. You will notice that the amount of coloring is very small in the low boiling fractions, but very high in the high boiling fractions, and conversely that the amount of paraffins and naphthenes in the low boiling fractions is very large while in the residue it is very small. Looking now at similar diagrams for a Paraffin Base Crude and an Asphalt Base Crude; you will notice first that the Paraffin Base Crude contains very little, the Asphalt Base Crude very much color or asphalt. Also that the Paraffin Base Crude contains very much and the Asphalt Base Crude very little paraffin and naphthenes. Also that the Paraffin Base Crude contains very little and the Asphalt Base Crude very much of the aromatic group. Such information as these charts set forth enable the refiner to decide what products he can make and indicate in a general way the methods he must follow. For example the charts would show: (1) The percentage of Gasoline that the Crude contains; (2) The percentage of Lamp Oil; (3) the percentage of Lubricating Oil, etc. However you will please understand that this is not a practical assay of Crude Oil. It is merely an attempt to give you a Chemical picture so to, speak, showing the distribution of the four important groups that the refiner has to deal with; also that each group consists of thousands of individual hydrocarbons that are never isolated even in the laboratory.

4. Now, starting with Crude Oil, it is the task of the refiner to isolate the commercial products that I have shown you. You will see the processes outlined on these two charts, and I wish to make especially clear that they represent two distinctly different methods of refining, so much so that one refiner may decide to use one of them to the exclusion of the other, or he may decide to use both of them. He will

be guided in this decision by his local conditions. If it be his desire to produce the maximum amount of gasoline and lamp oil he will use the method marked "*Cracking Distillation.*" If on the other hand he wishes to produce the maximum yield of the heavy Lubricating Oils and Petroleum Asphalts, he will use the method marked Fractional Distillations, which means that he will simply separate from the crude oil the various fractions which compose it, while the refiner who uses the cracking process actually breaks down these heavy fractions by destructive distillation in a manner similar to the production of benzol and gas by the destructive distillation of coal.

5. The first step in the cracking process is the cracking distillation. The crude oil is pumped into stills containing 500 to 1,000 barrels, which consist simply of horizontal steel cylinders made of sheets of half inch boiler steel riveted together and provided with man-holes on top and ends; with pipe for pumping oil into stills; with vapor line for conducting the distilled vapors to a condenser; with safety valve; with combustion chamber underneath; with fractional air condensers and with water condenser; and with pipe for conducting away the gases involved during the distillation.

FIG. 1. CRUDE STILL.

Such a still is nearly filled with, *e. g.*, Mid Continent crude oil and fires are lighted. When the temperature of the oil in the still has reached 175° to 200° F. some gases, consisting largely of britane and pentane, are given off and presently the highest naphtha starts to distill over. The firing is continued; the temperature in the still becomes gradually higher; the distillate becomes gradually heavier until the temperature in the still reaches about 325° F., at which point about 6% or 8% of crude naphtha (200° F. boiling point) has distilled over. This is set aside as Crude Naphtha. The distillation is continued until the temperature in the still has reached about 475° F. for crude heavy naphtha and represents 13% to 15% of the crude and has an average boiling point of about 300° F. The distillation is then continued until the temperature in the still has reached about 625° F. for Natural Lamp Distillate, which represents about 16% to 18% and has an average boiling point of about 450° F. When the still has reached this temperature, cracking or destructive distillation sets in. The fires are slackened in order to distill very slowly and this slow distillation is continued until the temperature in the still reaches 675° to 700° F., producing a distillate with an average boiling point of about 550° F., but containing some gasoline, some lamp oil and much heavier oil which I have designated as Gas & Fuel Oil stock. The yield of this oil is about 20%. You will notice that this cracking distillation is very different from an ordinary fractional distillation; heavy molecules have been broken down into lighter ones by submitting them to temperatures at which they are unstable.

There yet remains in the still a heavy black tar representing about 42% of the crude oil. This is the source of paraffin wax and the line of lubricating oils called Paraffin oils. It is no longer desirable to carry on a cracking distillation because this would result in the destruction of the valuable products desired. The distillation is continued in such a way as to avoid cracking as much as possible (is distilled fast) either in the same still or more commonly in separate smaller stills called Tar Stills. This Tar Still Distillation is carried on very rapidly in order to produce the maximum yield of paraffin distillate (about 22%). In addition to the paraffin distillate, there is also produced by destructive distillation about 15% of cracked distillate. At the end of the distillation the stream becomes so heavy that it will sink in water and is then known as Wax Tailings, which amounts to about 1% of the crude oil. When the distillation

stops there remains in the still nothing but Coke, amounting to about 4% of the crude oil.

Now taking up the various fractions; first the crude naptha. This is again distilled; first in order to separate it into the various gasolines and naphthas that compose it and secondly to separate it from the small amount of bottoms or light lamp oil that it contains. This is done in a still which is heated by steam usually by injecting live steam directly into the gasoline. When the distillation starts, some gas is given off, then the lightest distillate appears at the trap usually

FIG. 2. TAR STILL.

about 90° Be. gravity. The distillate gradually gets heavier until all the gasoline has distilled off. The receiver is then changed and the naphtha distillate is separated. At this point about 90% has distilled off leaving a bottom about 10%. This bottom is essentially lamp oil and is used as such. The heavy crude naphtha is handled in the same manner except that it contains little or no gasoline and contains about 50% of bottoms or lamp oil. The cracked distillate is also distilled with steam to remove about 4% of crude naphtha.

Up to this point all the operations have been different types of distillation. The next step in handling the naphtha distillate from both sources, the lamp oil distillate and the crude naphtha from cracked distillate and the test cracked distillate, is the acid treatment. You have seen in the crude diagrams that all the fractions contain a certain percentage of material attackable by sulphuric acid so that this re-agent affords a convenient means for removing color and odor from the remainder of the hydrocarbon distillate. In practice, the naphtha distillates are agitated with about 5% by volume, the lamp oil distillates with about 1.5% of sulphuric acid, oil of vitriol, for

FIG. 3. AGITATOR.

about a half hour. The color and odor bearing compounds combine with the acid producing a heavy black viscous mass called acid sludge, which settles to the botton of the vessel. The sludge is drawn off and the oil washed with water and alkali to remove all traces of acid and is then ready for the market.

The sludge fron all acid treatments is separated into unstable products. This is accomplished by boiling it with water, which results in the dilution of the acid and renders it incapable of holding

in solution the impurities. The weak acid (30° to 50° Be.) settles to the bottom, is drawn off and reconcentrated. The upper layer consisting of the impurities is known as acid oil. This acid oil is separated by fractional distillation into a light distillate which consists of all the evil odors that the original distillate contained and a residue consisting of the asphaltic compounds that were removed by the acid.

You now have before you all the processes used in the manufacture of naphtha and lamp oil, and while the ideas are fresh in mind I will be glad to have you question me on points that are not clear.

The next general subject is the handling of the paraffin distillate, which is the direct source of the paraffin wax and all of the paraffin oils. The first step is the process of cold pressing The distillate is first cooled to 20° to 30° F. by pumping through pipes surrounded by cold brine, thereby causing the paraffin wax (amounting to about 10% of the distillate) to solidify. This solid 10%, mixed with the 90% liquid oil, forms a soft mush which is pumped through a filter press. That which stays in the press is called the slack wax and amounts to about 20% of the paraffin distillate. The 80% that goes through is called pressed distillate. The slack wax, consisting of about equal parts of oil and wax, is then put through a process peculiar to the oil business, known as the sweating process. It consists of cooling the mixture until it has become a solid cake and then very gradually warming it. The crystals of the paraffin form a network through which the oil is distributed and when the mass is warmed the oil sweats out and drips away. It always carries with it some wax in solution, but the final result is that the oil all sweats out leaving the paraffin wax in a fairly pure state.

This sweating process separates the slack wax into crude paraffin wax and what is known as Foots Oil. The latter still contains much paraffin, which is removed by putting it again through either the cold pressing or sweating process.

The crude paraffin wax is then put through another process that is peculiar to the oil business, that of Clay or Bone Black percolation for the purpose of removing asphaltic coloring matter and thereby changing the crude paraffin to refined colorless paraffin. The clay used for this purpose has properties similar to those of bone black. *i. e.*, it absorbs and retains tarry and asphaltic compounds. It is

found in Florida and Georgia where it is mined, roasted, broken up and sifted to separate grains such as you see here. It is very porous and light, weighing only about 2-3 as much as water. This clay, or fuller's earth as it is commonly called, is put into large upright cylinders holding 10 or 20 tons and provided with a finely perforated bottom. The crude wax is melted and poured on top of the clay. It trickles down through the clay bed and passes through the perforated bottom. The first drippings from such a filter bed are absolutely colorless, but as the filtration progresses, the color becomes

FIG. 4. SWEATER.

more and more like crude wax. A ton of clay yields 5 or 6 tons of first quality paraffin wax. The amount of asphalt or coloring matter retained by the clay is exceedingly small and is removed by burning the clay in a cement kiln of the usual type, thus regenerating the clay for subsequent use.

I have explained that the paraffin distillate is the source of paraffin wax and light lubricating oils and have explained the various steps in the preparation of paraffin. The light lubricating oils are made from the filtrate from the cold presses—the pressed paraffin distillate—

by putting it through the process of fractional distillation, thereby separating it into a distillate of light oils that go to make up the gas and fuel oil stock and a residue in the still called paraffin oil stock, representing from 15% to 50% of the charge of the still depending on the quality desired.

This type of distillation is also peculiar to the oil business. The desired product is a heavy oil so that all cracking must be avoided in order to produce the maximum yield of this oil. The result is accomplished by using the very important process of distillation with bottom steam or fractional distillation. A still is charged with the pressed paraffin distillate and fires are lighted. The temperature in the still rises and when it has reached about 400° F., the distillation begins. Shortly after this the live steam is injected into the oil in distillation through perforated pipes placed near the bottom of the still. No water accumulates in the still because the temperature is so high. The steam passes upward through the oil as an inert gas and passes through the condenser with the oil vapors and is condensed there with the oil. The effect of this current of steam through the oil is exactly that of a vacuum distillation, *i. e.*, it lowers the boiling point of the oil in distillation and allows a heavy oil to be distilled at temperatures below the temperature of destructive distillation. You will notice that cracking sets in at about 630° F. Without the use of steam, the distillation in question would require that the still be heated to about 750° F. This would result in the destruction of the desired oil. With steam it can be carried on with a maximum temperature of 600° F., thus entirely avoiding destructive distillation.

The Paraffin oil stock is a dark colored unattractive looking material which is transformed into the valuable paraffin oils of commerce by treating with sulphuric acid in the manner already described. The treating loss in this case is from 10% to 30%. The whole cracking process described thus far is designed to produce the maximum yield of gasoline and lamp oil from crudes containing asphalt.

We will now turn to the method of refining the light colored non-asphaltic crude oils from which the valuable Cylinder oils may be made. The object in this case is to avoid all destructive distillation in order to produce the maximum yield of the very heavy lubricating oils. The still is charged with the crude oil, fires are lighted, the crude naphtha is distilled off as in the other distillations, but when

the temperature is well above the boiling point of water, steam is injected into the oil as before described. Under these conditions, the crude naphtha has distilled off when the temperature in the still has reached about 285° F., while without steam the still temperature was about 375° F. The yield from this kind of Crude is about 13%. The heating is continued, more and more steam being injected, the distillate becoming heavier and heavier until the heavy crude naphtha has distilled off. At this point, the temperature in the still has reached about 330° F., while without steam at this point the temperature was 475° F. The yield of this oil is about 13%. The distillation is still continued until the natural lamp oil distillate has distillated off. At this point, the temperature in the still is only 500° F., while without steam it was 630° F. Now instead of trying to induce cracking by slowing the rate of distillation, the amount of steam is increased and the distillation is carried on as fast as possible to avoid cracking. This is continued until the lubricating distillate, amounting to about 28% of the crude, has distilled over. At this point the temperature in the still has reached about 620° F., and the distillation is stopped, leaving the cylinder oil stock in the still. You will recall that in the cracking process the temperature in the still reached 850° F., and yielded a residue in the still of solid coke. This whole distillation has been conducted in such a manner as to produce the best quality and largest yield of this residual oil, the source of all steam cylinder oils.

The various fractions from the stills are put through exactly the same processes as the corresponding fractions from the cracking distillation, except the lubricating distillate. The crude naphtha and the crude heavy naphtha are fractioned and some of the distillates treated with acid.

The lamp oil distillate is treated with acid as before described. The lubricating distillate, amounting to about 28% of the crude, is put through the same process for the removal of wax and gas oil that the paraffin distillate was put through, the only difference being that the resulting lubricating stocks are not usually treated with sulphuric acid, but are brought to the desired color by percolating through fuller's earth to produce the neutral spindle oils of commerce.

The cylinder stock remaining in the still, and amounting to 8% to 13% of the crude oil, is ready for shipment as unfiltered cylinder oil. Or it may be percolated through clay to produce the filtered oils of

commerce. In order to show the wonderful effects of fuller's earth on the color of oils, I have selected a series of samples showing (1) cylinder stock that was pumped into the filter, (2) the first oil that percolated through, (3) a sample when the percolation was half completed, and (4) a sample at the end of the percolation. At this point the clay must be restored.

You will notice that I have described the cracking distillation of a mixed base crude and the fractional distillation of a paraffin base crude. Now, what would result if the mixed base crude had been put through the process of fractional distillation? The crude naphtha would of course distill off, then the crude heavy naphtha, then the natural lamp oil, then a distillate containing wax and lubricating oil corresponding to the lubricating distillate, leaving in the still a residue consisting of a soft pitch and amounting to about 15% of the crude oil. The maximum temperature in the still would be about 630° F. This residue has the property of being vulcanized by the action of air at about 500° F., or by sulphur at about 400°–450° F. This process is carried on in a still and consists in heating the residue to the desired temperature and pumping air through the mass for 1 to 2 days depending on the hardness desired. The resulting hard pitch is the petroleum road binder of commerce.

DISCUSSION

MR. IRISH.—I do not believe that I could attempt to say very much in opening this discussion, except that those of us who spend our time in the industry described in Mr. Robinson's paper realize that it has been very ably put before you; it has been very lucid and very concise. He has been dealing with a difficult subject to present even to an audience of engineers and chemists, and while it may not have, in all its details, appealed to those who are not versed in the art, it has been the very best exposition of the subject that I have ever heard. I shall be glad to assist Mr. Robinson in the discussion and answer any questions that may come up touching the practical side of the operation, while he will attend to the chemical side.

MR. PRICE.—Is the future supply of fuel oil or gasoline going to decrease as you continue those different methods of distillation? Also, is the Mexican crude oil, which I understand is on the market now in New York, going to be converted by the same general method of distillation, or will that be available for some years to come only as fuel?

MR. IRISH.—The supply of gas and fuel oils must necessarily be a function of the crude oil production of the world. While the amount of crude oil produced has within the past few years been greater than at any other time since the discovery of petroleum, and consequently indicates an ever increasing supply, we are at present and have been for the last two or three years, suffering from a falling off in our production. We are informed that the crude oil stocks in the

United States, east of the Rocky Mountains, are decreasing at the rate of about 40,000 barrels a day. That means to us that the supply has fallen off and the demand has increased, until the demand has overtaken the production, and we are drawing on accumulated stocks, and so long as that continues, exhaustion of the supply of gas and fuel oil will of course come nearer. But the supply of those oils has been supplemented by the Mexican crude to which Mr. Price referred. In Mexico, as in California, there are great deposits of petroleum, which as yet have only been explored in a very superficial manner. We are told that at the present time the bulk of the Mexican petroleum is being produced from only two wells located about 150 miles apart. One of these wells will flow naturally, if allowed to, at the rate of 37,000 barrels of oil a day, and the other one is shut in, with possibly a similar capacity. The Mexican crude is new to the refiner, and it would be unsafe and unwise to predict what can be made from it. We know it has an asphalt base, and is limited in possibilities to the production of those things Mr. Robinson has described as being peculiar to the asphalt base crude oil. It means that a large proportion of such crude oil will find its way into the fuel oil market as rapidly as it can be brought into this country and used.

MR. PRICE.—In the steam distillation, about what is the lowering in temperature that you obtain—about 100° F.?

MR. ROBINSON.—More than that, about 150° F.

MR. PRICE.—Well, when the natural lamp oil is distilled off with a cracking distillation, it would be about 630°, and with the natural lamp oil from the fractional distillate I think it is about 450°. Do you use a vacuum and save the steam?

MR. ROBINSON.—Yes.

MR. J. C. PARKER.—I would like to inquire what is the longest pipe line used?

MR. IRISH.—The pipe line system is complete from Oklahoma to the Atlantic coast, so that Oklahoma crudes are distributed in New York, Philadelphia and Baltimore. The experience with the pipe lines in California I can not describe with any accuracy at all, as I know but little more than the other members of the Club. There was a device, as referred to, attempted for handling those crude oils which were semi-solid as they came from the ground, and it was in part at least successful.

Q.—I understand there is quite a lot of gasoline in natural gas wells.

MR. ROBINSON.—The gas that comes with certain crude oils is technically speaking very wet, that is, it is very rich in hydrocarbons, such as pentane and butane. They separate those products and mix them successfully with heavier hydrocarbons in the refinery to produce gasoline. I do not know the amount, but I would say there is between 1,000 and 3,000 barrels a day.

MR S. M. SWAAB.—Is this cylinder oil used without any admixture of animal oil in the cylinder?

MR. ROBINSON.—Yes, the oil is a pure mineral oil. Certain users insist there shall be a small amount of animal or vegetable oil mixed with their steam cylinder oils, but it is never put in unless specified by the user.

JOHN FRITZ

(Honorary Member)

Elected to Membership May 4, 1901

Died February 6, 1913

The industries at Bethlehem temporarily suspended operations, stores were closed, schools dismissed, and the entire community joined in showing respect to the memory of John Fritz, when his body was conveyed to its last resting place on February 12th, 1913, escorted by the entire student body of Lehigh University. Men prominent in the engineering profession, in technical societies, in advanced education, in financial, industrial, mercantile, manufacturing and transportation interests from various parts of the country gathered at Bethlehem to attend the funeral.

This assemblage was not to recognize the achievements of a great general or a noted admiral, a distinguished judge, a prominent merchant or one who had won political preferment, but it was a tribute of respect and esteem for an American citizen, who from a most modest beginning had as an engineer won recognition by honors such as few have received and whose personality caused him to be loved by all with whom he came in close contact.

The ninety-one years of life alloted to John Fritz covered most of the industrial development of the United States, for at his birth in 1822 transportation was largely confined to vehicles drawn by horses, the canal system being in its infancy and railroads a novelty. Iron was then made only by the use of charcoal in forge fires or in blast furnaces whose average yearly output is represented by the daily production of modern furnace plants. Manual labor, supplemented by that of animals and by water power, were employed in producing and fabricating metal. But in his life John Fritz was conversant with all the steps in the advance of the transportation problems up to the great vessels which plow the waters of the oceans, lakes and rivers, to the railroads whose powerful locomotives and metal cars travel on 100 pound rails at phenomenal speed, carrying millions of passengers and millions of tons of freight. It was his privilege to observe the iron industry of his youth, which in the United States was then gauged by tens of thousands of tons, reach proportions where the annual product is measured in tens of millions of tons; and he saw

manual and animal labor displaced by power generated by the consumption of wood, coal, oil or gas; or the potentiality of falling water transformed into electrical energy for illumination and for operating industrial plants and railways. The introduction of the Bessemer, the open hearth and the electric steel processes, the continuous mills and all the manifold mechanical devices which have brought the iron and steel industry to its present controlling position, passed in review before his phyiscal vision, some of these developing from his fertile brain.

The transit from the boy driving a horse to pull a canal boat to the engineer and iron master who had received recognition by medals from the elevation to office in numerous scientific and technical societies demonstrate what may be accomplished by one without technical training who utilizes his best efforts and applies himself with a definite purpose.

While John Fritz won these honors and recognitions by his ability, persistence and industry, he realized the assistance of technical training, and his services as a trustee of Lehigh University and his beneficence in erecting a mechanical laboratory and providing for its maintenance, representing probably $250,000, demonstrated his desire to give to others help which he had been unable to secure.

FRANK BURNS

Elected to Active Membership

October 17, 1908

After an illness extending through four months, during which he showed remarkable uncomplaining patience, Frank Burns died on the eleventh of March.

He was born in Philadelphia in the year 1844, the son of the late Charles Marquedant Burns and his wife, Eliza van Dyke, whose maiden name was Rousseau.

He attended classes at the Episcopal Academy and at the University of Pennsylvania, then on Ninth Street, where the Post Office now stands, leaving at the close of the Junior year (Class of '62). Soon after, he enlisted in the Fifteenth Pennsylvania Cavalry

("Anderson Troop") United States Volunteers, and was present at the Battle of Antietam. For a time he was in business in New York and afterwards in Philadelphia. For the past fifteen years he has been a faithful employe of the Survey Bureau of the City of Philadelphia, mainly as draftsman and designer in the Bridge Department, where he was recognized as an indefatigable worker and an expert in perspective.

He was of a most kindly and retiring disposition, having a great aversion to social prominence. He was unmarried. He was a member of St. Andrew's Society, the Naval Order, Manufacturers' Club, the Engineers' Club of Philadelphia, the Alumni Society of the University of Pennsylvania and the Geographical Societies of Washington and of Philadelphia.

EUGENE E. DUNLAP

(Active Member)

Elected to Membership December 7, 1907

Died January 16, 1913

Eugene E. Dunlap, son of the late Charles W. and Elizabeth B. Dunlap, was born at Philadelphia, March 9th, 1878.

He was educated in the public schools, graduated from the Philadelphia Central High School in 1897, and University of Pennsylvania, in 1901.

In September, 1901, he associated himself with the N. Z. Graves Co., manufacturers of paints, varnishes, etc., as a chemist, and remained with them until his death

Mr. Dunlap was a member of the Priestly Club, American Chemical Society and the Engineers' Club of Philadelphia.

Mr. Dunlap was a contributor to the "American Chemical Journal," and other scientific publications.

PAPERS SCHEDULED FOR THE SPRING TERM

The meetings committee beg to announce that the following papers have been scheduled for the spring term:

April 5—THE PANAMA CANAL
—*By Rear Admiral C. M. Chester (Retired)*

April 19—HIGH PRESSURE FIRE SERVICE
—*By John E. Codman*

May 3—TRANSPORTATION
—*By Lt. Col. Jos. E. Kuhn, U. S. A.*

May 17—PUBLIC UTILITY REGULATION IN WISCONSIN
—*By Prof. W. D. Pence*

June 7—SUCTION GAS PRODUCER ENGINE VS. COMPOUND CONDENSING CORLISS CRANK AND FLY WHEEL PUMPING ENGINE
—*By J. E. Gibson (Active Member)*

ANNUAL REPORT OF THE BOARD OF DIRECTORS FOR THE FISCAL YEAR, 1912

JANUARY 25, 1913.

To the Members of the Engineers' Club of Philadelphia:

The Board of Directors herewith presents its report for the year ending December 31, 1912, as follows:

Eighteen stated and two special meetings of the Club were held, at which the maximum attendance was 205 and the average 86. Nine regular, two adjourned and two special meetings of the Board of Directors were held.

The summary of membership on December 31, 1912, as compared with the summary of December 31, 1911, is as follows:

	1911			1912		
Class	*Resident.*	*Non-Resident.*	*Total.*	*Resident.*	*Non-Resident.*	*Total.*
Honorary	2	2	4	1	2	3
Active	361	92	453	351	107	458
Associate	59	7	66	61	7	68
Junior	52	12	64	61	9	70
	474	113	587	474	125	599

Thirty-four active, five associate and twenty-eight junior members were elected; two associate members were transferred to the active grade, twelve juniors to the active grade and four juniors to the associate grade; five active, one associate and one honorary member died; twenty-seven active, two associate and five junior members resigned; twelve active, one associate and one junior member were dropped from the rolls, and one active member was reinstated to membership.

The record of deaths is: Melbourne E. Davis, active member, died December 22, 1911; W. C. Wetherill, active member, died January —, 1912; C. H. Ott, active member, died January 4, 1912; Charles I. Young, active member, died January 6, 1912; Francis J. Drake,

associate member, died February 7, 1912; George W. Melville honorary member, died March 17, 1912; H. W. Spangler, active member, died March 17, 1912.

Two social entertainments were held during the year. A reception and dance was held on May 10, 1912, the expenses of which were met by subscription, and a smoker on November 9, 1912, the expenses of which were defrayed from the Club funds. Both of these functions were well attended and successful in every way.

Attention is called to the excellent financial condition of the Club. While the net gain is less than in 1911, it is due to the fact that practically all of the uncollectable debts have been eliminated, leaving the accounts receivable of $3,792.83 a very good asset. Both the technical and financial status of the Club are better than at any other time in its history.

The Club is rapidly becoming the technical center of Philadelphia, as the Phila. Chapter Amer. Inst. Elec. Engineers, Phila. Chapter Amer. Soc. Mech. Engineers, Phila. Chapter American Chemical Society, Municipal Engineers of the City of Philadelphia, Delaware River Society of Marine Draftsmen and the Aero Club of Pennsylvania are holding meetings in the Club house. The members of the Engineers' Club are always welcome at any of the meetings of these societies, thus giving them an opportunity to come in contact with these various technical activities.

The following papers have been presented before the Club:

January 6—"Propulsive Machinery and Oil Fuel in the U. S. Naval Service." Capt. C. W. Dyson, U. S. N.

January 20—"Sub-aqueous Tunneling." Henry Japp.

January 27—"Dock Facilities in New York City; Present Facilities, Proposed Improvements and Extensions." W. J. Barney, Deputy Commissioner, Dept. of Docks, New York City.

February 3—Annual Address—"Ostwald's Energetics as a Moral Force and Law," and "Ives' Colorimeter and Color Photography." President Henry Hess.

February 10—"Hydraulic Gold Mining in British Columbia." Howard W. DuBois.

February 17—"The Development of Roentgenology." H. Clyde Snook.

March 2—"Smokeless Powder and High Explosives for Military Uses." Lt. Col. Odus C. Horney, U. S. A.

March 16—"Stellar Evolution." Dr. John A. Brashear, of Pittsburgh, Pa.

April 6—"Recent Improvements in Street Pavements." George W. Tillson.

April 20—"The Gas Producer." H. E. Longwell, Consulting Engineer, Westinghouse Machine Co.

May 4—"The Engineer in His Relation to the City Plan." Nelson P. Lewis, Chief Engineer, Board of Estimate and Apportionment, New York City.

May 18—"The Significance of 'The Middle Third,'" and "The Behavior of Cast Zinc Under Compression." John C. Trautwine, Jr.

June 1—"The Queen Lane Filtration Plant." S. M. Swaab.

September 21—"The importance of Meteorological Data in Engineering." George S. Bliss, Director, Climatological Service of Penna.

October 5—"The Exhibition for the Abatement of the Smoke Nuisance Held in London, Spring of 1912," George H. Perkins, of the Lowell Institute of Technology. "Methods and Means of Smoke Abatement," O. R. McBride, of the University of Pittsburgh.

October 19—"The Development of Separately Moulded Structural Concrete." C. D. Watson.

November 2—"Sanitary Protection of the Water Supplies Taken from the Great Lakes." Prof. G. C. Whipple.

November 16—"The Mechanics of the Aeroplane." Henry M. Neely.

December 7—"The Planning of City Streets." B. A. Haldeman, Engineer, General Plans Division, Survey Bureau, Philadelphia.

December 21—"Manufacture of Petroleum Products." F. C. Robinson, Chief Chemist, Atlantic Refining Company."

FINANCIAL REPORT

Statement of Assets and Liabilities as at December 31, 1912

ASSETS

Cash—Colonial Trust Co.—Active Account	$329.25	
Colonial Trust Co.—Interest Account	1,615.00	
In Office	549.09	
		$ 2,493.34
Accounts Receivable Members' Ledger		3,792.83

INVENTORY OF SUPPLIES ON HAND

Wines and Liquors	267.37	
Cigars	174.15	
Fuel	26.12	
Restaurant Provisions	143.40	
House	50.43	
		661.47

PROPERTY

Building No. 1317 Spruce Street	72,850.00	
Furniture and Fixtures—House	9,181.69	
Furniture and Fixtures—Restaurant	1,330.84	
Library	2,100.00	
		85,462.53

INSURANCE

Perpetual on Club House	1,782.00	
Unexpired on Furniture	7.86	
		1,789.86

MISCELLANEOUS

F. H. Stier, Treasurer	153.50
Total Assets	$94,353.53

LIABILITIES

Accounts Payable		$ 3,292.72
Bills Payable—Building Account	$8,100.00	
Bills Payable—Regular Account	1,500.00	
		9,600.00
First Mortgage Payable	40,000.00	
Second Mortgage Bonds	25,250.00	
		65,250.00
Accrued Interest—First Mortgage	1,080.00	
Accrued Interest—Second Mortgage Bonds	1,615.00	
		2,695.00
Link Belt Company, Second Mortgage Bond Account		529.58
Trustees of Bond Redemption Fund		36.20
Appropriation from Junior Section to Library Committee		203.49

CHRISTMAS FUND

Balance, January 1, 1912	$ 60.00	
Contributions, December, 1912	285.50	
	345.50	
Disbursements, December, 1912	246.50	
		99.00

CAPITAL ACCOUNT

Surplus as at January 1, 1912	11,422.28	
Reserve for Redemption of Second Mortgage Bonds, Link Belt Co. Account	295.42	
	11,717.70	
Suspense Account, Uncollectable Accounts Previous to January 1, 1912	695.87	
	11,021.83	
Gain for year 1912 as per Statement of Income and Expense.	1,625.71	
Surplus as at December 31, 1912		12,647.54
		$94,353.53

Statement of Income and Expense, Year Ending December 31, 1912.

INCOME

Dues—Net		$16,126.59	
Initiation Fees		1,370.00	
PUBLICATIONS			
Advertising—Directory	$410.00		
Advertising—Proceedings	527.35		
Sales—Directory	2.50		
Sales—Proceedings	103.70		
		1,043.55	
MISCELLANEOUS			
Badge Sales	26.00		
Excess and Deficiency of Cash	.50		
Interest on Deposits, Active Account	18.46		
Interest on Deposits, Interest Account	3.61		
Reprint Sales	27.00		
Telephone Receipts	162.28		
		237.85	
CLUB HOUSE BUSINESS			
Billiards and Pool Sales	219.62		
Cigar Sales	2,419.10		
Lodging	3,684.73		
Rent of Meeting Room	334.00		
Restaurant Sales	9,152.08		
Wine Sales	1,329.09		
		17,138.62	
Total Income Year Ending December 31, 1912			$35,916.61

Expenses

Salaries and Wages

Manager's Salary, May 1 to Dec. 31	$1,200.00	
House Salaries and Wages	3,217.45	
Office Salaries	2,750.70	
Restaurant Salaries and Wages	4,574.22	
		$11,742.37

Expense

House Expense	1,137.91	
Office Expense	427.75	
Directors' Expense	20.25	
Library Expense	61.40	
		1,647.31

Publications

Directory Publishing	320.19	
Proceedings Publishing	1,076.67	
		1,396.86

Miscellaneous

Badge Purchases		13.55	
By-Laws Revision		53.30	
Entertainment Committee		167.50	
Fuel Purchases	$544.70		
Inventory Jan. 1, 1912	18.20		
	$562.90		
Inventory Dec. 31, 1912	26.12		
		536.78	
Gas and Electricity		1,189.68	
Insurance		51.00	
Meetings Committee		550.00	
Membership Committee		133.81	
Reprint Purchases		26.50	
State Tax on Bonds		101.00	
Taxes and Water Rent		943.00	
Telephone Expense		363.78	
Club Luncheons		354.00	
			4,483.90

Interest and Discount

Interest on First Mortgage	2,160.00	
Interest on Second Mortgage Bonds	1,262.50	
Interest on Building Fund Notes	425.81	
Discount on Notes	15.00	
		3,863.31

CLUB HOUSE BUSINESS

Billiards and Pool Purchases	$ 28.74	
Cigar Purchases	2,027.25	
Wine Purchases	1,036.01	
		3,092.00
Restaurant Expense	$ 835.41	
Restaurant Provision Purchases	7,303.82	
		8,139.23
		$11,231.23

INVENTORY, DECEMBER 31, 1912

Cigars	$174.15	
Restaurant Provisions	143.40	
House Supplies	50.43	
Wines and Liqours	267.37	
		635.35

INVENTORY, DECEMBER 31, 1911

Cigars	$195.57	
Restaurant Provisions	103.19	
Wines and Liquors	262.51	
	561.27	
Deduct Increase in Inventory	74.08	
Expense of Club House Business		11,157.15
Total Expense		34,290.90
Net Gain for Year 1912		$ 1,625.71

Respectfully submitted,
F. H. STIER, *Treasurer.*

Audited and found correct.

STOCKTON BATES, C. P. A.,
For Stockton Bates & Sons.

The following is the report of the Trustees of the Bond Redemption Fund:

Fifth Annual Report of the Trustees of the Bond Redemption Fund. Being a Statement of Business for the Year 1912.

RECEIPTS

1912	
January 1, Balance from 1911	$33.20
January 1, Refund of Box Rent	3.00
	$36.20

EXPENDITURES

October 17, Transferred to Treasurer of Club, Temporarily Closing Account.....$36.20

The Trustees hold no negotiable securities.

HENRY LEFFMANN,
EDWIN F. SMITH,
EDGAR MARBURG,
Trustees.

Respectfully submitted,
THE BOARD OF DIRECTORS,
HENRY HESS, *President.*
W. P. TAYLOR, *Secretary.*

ABSTRACT OF MINUTES OF THE CLUB

Regular Meeting, January 4th, 1913

The meeting was called to order at 8:35 P. M., with 75 members and visitors in attendance. The minutes of the Business Meeting of December 21st were approved as printed in abstract.

Mr. E. M. Nichols announced that Mr. W. L. Plack had withdrawn his name as a candidate for President.

Mr. Morris Knowles presented the paper of the evening, entitled, "Wise Utilization of the Water Resources of Pennsylvania," which was discussed by Messrs. John C. Trautwine, Jr., and J. E. Gibson.

On motion of Mr. Trautwine a vote of thanks was extended to Mr. Knowles for his paper.

Business Meeting, January 18th, 1913

The meeting was called to order at 8:30 P. M., with 75 members and visitors in attendance. The minutes of the Regular Meeting of January 4th were approved as printed in abstract.

The following were reported as having been elected to membership by the Board of Directors at their meeting of January 16th, 1913: Active, John A. Coyle and Walter Dalton; Associate, John C. Bartlett, Hen y Franz and George Wood; Junior, William F. Carson and W. A. Sloan.

Dr. George Otis Smith, Director of the U. S. Geological Survey, presented the paper of the evening, entitled "The Engineer's Interest in Public Land Questions," which was discussed by Messrs. W. F. Ballinger, E. M. Nichols, H. W. DuBois, Dr. H. M. Chance, Dr. Carl Hering, W. C. Furber, A. E. Lehman, John C. Parker, P. A. Maignen, R. G. Develin, H. C. Berry and S. M. Swaab.

On motion of Mr. Hutchinson a vote of thanks was extended to Dr. Smith for his paper.

Thirty-Fourth Annual Meeting, February 1. 1913

The meeting was called to order at 8:45 P. M. by President Hess, with 125 members and visitors in attendance. The minutes of the Business Meeting of January 18 were approved as printed in abstract. The Annual Report of the Board of Directors was presented and approved.

It was moved and unanimously carried that the next meeting be made a Business Meeting, to discuss the question of revision of the Charter.

President Hess, after relinquishing the chair to Vice-President Mebus, delivered his farewell address.

The tellers announced that 150 legal ballots had been cast, and the following were elected as officers of the Club for 1913:

President, W. P. Taylor; Vice-President, S. M. Swaab; Secretary, E. E. Krauss; Treasurer, J. Reese Bailey; Directors, J. E. Gibson, Manton E. Hibbs, H. Clyde Snook, F. K. Worley.

Business Meeting, February 15, 1913

The meeting was called to order at 8:25 P. M., by President Taylor, with 98 members and visitors in attendance.

The following action of the Board of Directors, taken at their meeting on February 13, 1913, was reported:

Mr. Wm. Copeland Furber was unanimously elected to fill the vacancy in the Board of Directors caused by the election of Mr. S. M. Swaab to the Vice-Presidency.

The Secretary reported the following deaths:

Eugene E. Dunlap, elected to active membership December 7, 1907 who died January 16, 1913.

John Fritz, honorary member, elected May 4, 1901, who died Februa y 13, 1913.

On motion the President was instructed to appoint a committee to prepare a memoriam on the death of John Fritz, honorary member. The president appointed the following committee: John Birkinbine, Edwin F. Smith, Joseph T. Richards and J. Chester Wilson.

The Secretary announced the election by the Board of Directors at their meeting on February 13, 1913, of the following new members:

Active Members—C. Willis Adams, H. Bruce Armstrong, Horace C Dickey, Henry J. Edsall, Robert H. Fernald, Erskine Hazard, Walter S. Hine, Joseph A. MacLennan, Horace E. Rice, Coleman Sellers, Jr.; James Smith Watson, R. Wayne Wetherill.

Associate Members—Joseph W. Breen, Charles E. Coburn, J. Richard Jackson, Leslie S. McPherran, Richard G. Ward.

Junior Members—Charles D. Williams.

The question of the revision of the Charter was discussed and the following resolution unanimously adopted:

Resolved, That the Board of Directors be authorized to obtain a Charter, which, while preserving the intent of the present Charter, will eliminate its inconsistencies.

Mr. Manton E. Hibbs, active member, presented the paper of the evening, entitled "The Unwritten Law," which was discussed by Messrs. E. M. Nichols, W. C. Furber, W. F. Ballinger, E. Perrot, H. H. Quimby, John C. Trautwine, Jr. and D. E. Dallam, Chairman of the Legislative Committee of the Real Estate Brokers' Association.

Regular Meeting, March 1st, 1913

The meeting was called to order at 8:45 P. M. by Vice-President Swaab, with 80 members and visitors in attendance. The minutes of the meeting held on February 15th, 1913, were approved as printed in abstract.

Mr. Francis Donaldson, Chief Engineer, T. A. Gillespie Company, New York, N. Y., presented the paper of the evening, entitled, "The Sinking and Lining of Shafts," which was discussed by Messrs. Eli T. Conner, H. M. Chance, W. C. Furber and S. M. Swaab.

A vote of thanks was extended to Mr. Donaldson for his interesting paper.

ABSTRACT OF MINUTES OF THE BOARD OF DIRECTORS

REGULAR MEETING, January 16th, 1913.—Present: President Hess, Vice-President Mebus, Directors Worley, Vogleson, Berry, the Secretary and the Treasurer. Dr. Henry Leffmann, Chairman of the Trustees of the Bond Redemption Fund, was present, upon request, in order to advise the Board relative to the establishing of a special sinking fund for bond redemption.

The Treasurer's Annual Report, certified to by the auditors, was read and approved.

The Secretary's report and the annual report of the Board of Directors were read and approved.

The following resignations were read and accepted: W. K. Martin, C. W. Simon, R. H. Klauder, C. D. Ehret, John Meigs, S. E. Fairchild, Jr., R. K. Sheppard, Philip L. Spalding, George L. Thompson, J. A. Colby, J. O. Clarke and A. J. Menocal.

Mr. E. M. Bassett was reinstated to membership as of July 1st, 1912.

On motion, the Secretary was instructed to draft a set of resolutions in regard to Mr. Hewitt's resignation, and transmit the same to Mr. Hewitt, with a letter.

Reports of the Publication Committee, House Committee, Library Committee and Committee on Public Relations were presented and approved.

The Membership Committee's report was read and approved, and the following were elected to membership:

Active: John A. Coyle and Walter Dalton.

Associate: John C. Bartlett, Henry Franz and George Wood.

Junior: William F. Carson and W. A. Sloan.

The report of the Business Manager was presented and approved.

The matter of legal quorum was reported by the special committee on this question, and the report was accepted and the Committee discharged with thanks. The entire matter was then referred to Mr. Mebus, with authorization to refer the same to a competent attorney for his advice as to the legality of the various questions raised, report to be made at the next Board meeting.

The Business Manager was authorized to negotiate a liability insurance with the firm of Hoskins and Howell, premium of $43.74 to be paid, covering a period of three years.

It was moved and carried that the Manager's contract be continued.

The Business Manager was instructed to secure, free of cost to the Club, except for the cost of installation, the loan of a meter for a month, to determine the Watt consumption of the pump.

Upon report from the Manager regarding Mr. B. J. Sullivan's account, the Treasurer was ordered to cancel Mr. Sullivan's account from the books and strike his name from the rolls.

It was moved and carried that the sum of $850.00 previously provided for (See minutes May 19, 1910) be increased, so that $500.00 in addition to the interest be applied for this purpose within the next three months.

It was moved and carried that the privilege of using the Club as a meeting place for outside organizations be restricted to technical and semi-technical organizations.

It was moved and carried that the donation for the establishing of a sinking fund for retirement of second mortgage bonds be accepted with thanks, in accordance with the deed of gift as presented at this meeting.

ORGANIZATION AND REGULAR MEETING, February 13th, 1913.—Present: President Taylor, Vice-President Plack, Mebus and Swaab, Directors Hibbs, Gibson, Yarnall, Gilpin, Vogleson, the Secretary and the Treasurer.

The vacancy in the Board of Directors caused by the election of S. M. Swaab to the Vice-Presidency was filled, in accordance with the By-Laws, by the unanimous election of W. C. Furber, term to expire February, 1915.

The following Committees were then appointed for the year 1913:

STANDING COMMITTEES

Finance: J. A. Vogleson, Charles F. Mebus, S. M. Swaab, Henry Hess, J. M. Dodge.

House: F. K. Worley, W. L. Plack, J. A. Vogleson, G. F. Pawling, H. A. Moore.

Membership: Charles F. Mebus, R. G. Develin, H. C. Snook, H. H. Quimby, W. P. Dallett.

Meetings: S. M. Swaab, B. A. Haldeman, D. R. Yarnall, Wm. Easby, Jr., J. B. McCord.

Publication: M. E. Hibbs, J. E. Gibson, Richard Gilpin, G. W. Hyde, E. M. Evans.

Library: B. A. Haldeman, H. C. Berry, W. C. Furber (Two to be appointed).

Publicity: J. R. Bailey, D. R. Yarnall, St. G. H. Cooke, G. T. Gwilliam. H. B. Allen.

Advertising: M. E. Hibbs, J. E. Gibson, Richard Gilpin, G. W. Hyde, E. M. Evans.

SPECIAL COMMITTEES

Lantern: B. A. Haldeman, E. J. Dauner, H. E. Ehlers, A. D. Morris, Charles E. Bonine.

By-Laws: S. M. Swaab, Charles F. Mebus, W. P. Dallett, Edwin F. Smith, Carl Hering, H. A. Moore.

Art: W. L. Plack, David Halstead, George T. Gwilliam.

Public Relations: H. H. Quimby, Edgar Marburg, A. C. Vauclain, Henry Leffmann, John C. Trautwine, Jr., Edwin F. Smith, Charles Hewitt, W. L. Plack, Charles F. Mebus, S. M. Swaab, Henry Hess, W. P. Taylor.

The Temporary Membership Committee, consisting of Charles F. Mebus, S. M. Swaab and F. K. Worley, reported on the applications before the Board, and the following were elected to membership:

Active—C. Willis Adams, N. Bruce Armstrong, Horace C. Dickey, Henry J. Edsall, Robert H. Fernald, Erskine Hazard, Walter S. Hine, Joseph A. MacLennan, Horace E. Rice, Coleman Sellers, Jr., James Smith Watson, R. Wayne Wetherill.

Associate—Joseph W. Breen, Charles E. Coburn, J. Richard Jackson, Leslie S. McPherran, Richard G. Ward.

Junior—Charles D. Williams.

The resignations of E. H. Zieber and Stanley G. Child were accepted as of December 31, 1912.

The report of the Business Manager was read and the following action taken on the matters presented:

1. The Business Manager was authorized to dispose of the old typewriters and purchase a new one at a cost not to exceed the list price of $100.00, less whatever discount could be obtained.

2. It was decided that letters relative to delinquent accounts be sent out over the signature of the Treasurer, as in the past.

3. The Business Manager was authorized to act as Trustee of the Christmas Fund, which was deposited in the Western Savings Fund Society, under "J. M. Ritchie, Trustee."

4. The question of the papering and painting of the meeting room was referred to the House Committee.

The death of Mr. E. E. Dunlap was announced, and the Treasurer was ordered to strike off his dues for the first half of 1913.

Copy of a letter sent by Mr. Henry Hess to Prof. Ira N. Hollis, President of the Engineers' Club of Boston, was read and ratified by the Board; and, on motion, the Board extended the privileges of this Club to the Engineers' Club of Boston.

Mr. E. P. Haines and Mr. William Vollmer were transferred to non-resident membership as of January 1, 1913.

In view of the fact that the question of Revision of the Charter or the securing of a new Charter is to be considered at the meeting of the Club on February 15th, the President appointed Messrs. Charles F. Mebus, S. M. Swaab and J. A. Vogleson to constitute a Committee to proceed with this matter along the lines adopted by the Club at the next meeting.

The Treasurer was instructed to prepare a list of delinquent accounts and present the same at the next meeting of the Board.

REGULAR MEETING, March 13, 1913.—Present: President Taylor, Vice-Presidents Plack, Mebus and Swaab, Directors Develin, Gilpin, Vogleson, Haldeman, Yarnall, Hibbs, Worley, the Secretary and the Treasurer.

The President appointed the following to serve on the Library Committee: F. N. Morton, A. L. Magilton.

Meetings Committee: W. C. Furber.

The Chairmen of the Publication-Advertising Committee and By-Laws Committee were authorized to make appointments to fill the vacancies in their Committees.

The Board elected the following members to serve as Tellers for the year 1913: E. J. Dauner, L. H. Kenney, G. Wise.

The Treasurer reported a net gain to March 1st of $1,038.11, as compared with $68.19 for the same period of 1912.

The resignation of W. J. Taggart was presented and accepted.

The House Committee's report was read, and the following action taken in connection therewith:

Appropriation not to exceed $200.00 was made to the House Committee for the purpose of holding an Annual Reception during the month of April; and appropriation not to exceed $160.00 was made to the House Committee for the purpose of papering and repainting the meeting room.

The Membership Committee presented its report and the following were elected to membership:

Active—C. Burke Filbert, Edward C. Fish, William C. Greany, Donald B. Heilman, John H. Neeson, Joseph C. Rock.

Associate—Frank B. Johnston, Jacob T. Swartz.

Junior—Howard H. Demmert, William N. Edwards, Erle C. Herman, Charles C. Jones, Charles L. Downs, Carl A. Woerwag.

Robert F. Runge was transferred from Junior to Associate membership.

Reports of the following Committees were read and approved: Meetings, Publication-Advertising, Library, Public Relations and By-Laws.

The report of the Business Manager was read and approved.

The following members were dropped from the roll and their accounts charged into suspense: J. Kay Little, W. J. Spencer, P. H. Wilson.

The following resolution was passed relative to securing an extension of time for the first mortgage:

Resolved, that the President and Treasurer be and are hereby authorized to execute the agreement of extension of the first mortgage of $40,000.00 on the Club property for a period of three years from the twenty-sixth day of December, A. D., 1912.

Captain St. George H. Cooke presented his resignation as a member of the Board of Directors, which was accepted with regret, and Mr. Henry Hess was unanimously elected to fill this vacancy, term to expire February, 1914.

An appropriation of $203.49 was made to the Library Committee, this being the amount donated to the Club by the Junior Section.

The Publication-Advertising Committee was instructed to publish in the coming Proceedings short memoriams of Frank Burns and E. E. Dunlap.

THE ENGINEERS' CLUB OF PHILADELPHIA

1317 Spruce Street

OFFICERS FOR 1913

President
W. PURVES TAYLOR

Vice-Presidents

Term Expires 1913
W. L. PLACK

Term Expires 1914
CHARLES F. MEBUS

Term Expires 1915
S. M. SWAAB

Secretary
EDW. E. KRAUSS

Treasurer
J. REESE BAILEY

Directors

Term Expires 1914	*Term Expires 1915*	*Term Expires 1916*
R. G. DEVELIN	H. C. BERRY	J. E. GIBSON
RICHARD GILPIN	B. A. HALDEMAN	H. CLYDE SNOOK
J. A. VOGLESON	S. M. SWAAB	MORTON E. HIBBS
HENRY HESS	D. ROBERT YARNALL	J. FRANK WORLEY

Trustees of the Bond Redemption Fund
HENRY LEFFMANN, Chairman EDGAR MARBURG EDWIN F. SMITH

STANDING COMMITTEES

House—F. K. WORLEY, W. L. PLACK, J. A. VOGLESON, G. F. PAWLING, H. A. MOORE.

Meetings—S. M. SWAAB, B. A. HALDEMAN, D. R. YARNALL, J. B. MCCORD, W. C. FURBER.

Membership—CHAS. F. MEBUS, R. G. DEVELIN, H. C. SNOOK, H. H. QUIMBY, W. P. DALLETT.

Finance—J. A. VOGLESON, CHAS. F. MEBUS, S. M. SWAAB, HENRY HESS, J. M. DODGE.

Publication—M. E. HIBBS, J. E. GIBSON, RICHARD GILPIN, G. W. HYDE.

Library—B. A. HALDEMAN, H. C. BERRY, W. C. FURBER, F. N. MORTON, A. L. MAGITLON.

Publicity—J. R. BAILEY, D. R. YARNALL, F. K. WORLEY, G. T. GWILLIAM, H. B. ALLEN.

Advertising—M. E. HIBBS, J. E. GIBSON, RICHARD GILPIN, G. W. HYDE.

MEETINGS

Annual Meeting—1st Saturday of February, at 8:15 P. M.

Stated Meetings—1st and 3d Saturdays of each month, at 8:15 P. M., except between the fourteenth days of June and September.

Business Meetings—When required by the By-Laws, when ordered by the President or Board of Directors, or on the written request of twenty-five Voting Members of the Club.

The Board of Directors meets on or before the 3d Saturday of each month, except June, July and August.

Editors of other technical journals are invited to reprint articles from this journal, provided due credit be given the PROCEEDINGS

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE—The Club as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XXX JULY, 1913. No. 3

PAPER NO. 1123

WISE UTILIZATION OF WATER RESOURCES OF PENNSYLVANIA

BY MORRIS KNOWLES, M. Am. Soc. C. E.

Read January 4, 1913.

WATER AS WEALTH

It is unfortunately true that frequent use of words, originally rich in meaning, ends by making them colorless. So there is danger that, in talking so much of the conservation of water resources, we may forget what omnipresent natural wealth water really is, and fall short of a full appreciation of the part that it plays in our lives, and of the tremendous riches this bounteous gift of nature represents.

Roughly, the amount of water that falls annually upon the surface of the State of Pennsylvania is 30,000 billion gallons, and probably half of this, or 15,000 billion gallons, leaves the State to find its way to the ocean through our three great river systems and a few minor channels. Of the remainder that evaporates into the atmosphere, to return to us again; or of the portion absorbed by the earth, joining the great subterranean reservoir, or making possible the sylvan beauty and agricultural wealth of our State,

we do not now speak. Nor need we consider that this particular natural resource, unique and irreplaceable, forming 80 per cent. of the bodily tissue of each of us, and constituting an absolute non-substitutive requirement, is of a value utterly incapable of expression in terms of wealth.

It is worth while, however, to pause and contemplate what enormous wealth is represented to the imagination by the idea of complete, intensive use, throughout every year to come, of this 15,000 billion gallons of water per year. A staggering idea, truly! and yet, let imagination run riot there for a moment. Conceive

FIG. 1. BAD EMS, VIEW FROM PARK.

Showing improved conditions on the Lahn River near its confluence with the Rhine; about 200 miles from the mouth of the Rhine.

this great volume of water, controlled by the works of man for the benefit of the people of Pennsylvania. Imagine it protected in purity, flowing evenly throughout the year in smooth channels; bearing upon its surface everywhere, the commerce which such a condition would make possible; turning, with every ounce of its God-given power, the wheels to light and heat the homes, to pull the cars and trains, and to operate the industries of this community.

Three hundred billion gallons would more than suffice for all the domestic, municipal and industrial needs of the entire population of the Commonwealth—and almost all of this might be returned to the streams for other uses without nuisance. In descending from its point of precipitation to where it finally leaves the state, every drop of water gives up the quota of potential energy it has taken from the sun, amounting altogether to at least 3,500,000 horse-power; enough to supply all the manufacturing industries, street railways, and central electric light and power stations in the Commonwealth! How many times the present total of 50,000,000

FIG. 2. COMMUNAL FARMING, SALT RIVER IRRIGATION PROJECT; TEMPE, ARIZONA.

Roosevelt Dam, constructed of cyclopean-rubble-masonry; 340,000 cu. yds.; height, 280 ft.; capacity, 1,284,000 acre-feet; develops 4,400 H. P. To irrigate 240,000 acres.

tons of freight now transported annually on the water-ways of the state and borders, could be moved, can only be vaguely imagined. Bacon was indeed right when he described rivers as "the richest mines above ground!"

This, then, is the dream of the water conservationist in Penn-

sylvania. Fifteen thousand billion gallons of water a year to be harnessed by man to his purposes—all to be used in the ways that will most promote the public welfare, and none to leave the State until every particle of energy in it, capable of appropriation, has been taken. Thriving, healthy, populous communities, prosperous in industry, successful in commerce, living in peace and safety beside smoothly running water—true conservation! It is a dream of course; and complete utilization is admittedly impractical in the present. Yet we have seen man make the arid desert blossom

FIG. 3. BALTIMORE AND OHIO RAILROAD STATION, PHILADELPHIA, PENNA. Waiting Room during the flood of March 1, 1912.

as the rose; and where, in certain instances, he has applied his will to the problem, he has shown that he can enslave the torrent. Have we not reason to hope that much of our dream may come true, that this completeness of water utilization may yet be approximated, if not reached? When that day comes, we may well join with Gibbon in the belief that, "The servitude of the rivers is the noblest and most important victory which man has obtained over the licentiousness of Nature."

The Other Side of the Picture

How far we still are from the realization of this dream comes forcibly home to us when we turn from this pleasant picture to stern reality. How have we shown our appreciation of this wealth which nature constantly showers upon us? What are we doing to protect, control and utilize this 15,000 billion gallons of water?

If the author answers these questions chiefly with examples from Western Pennsylvania, he hopes you will understand that it is only because his work on the Engineering Committee of the Pittsburgh Flood Commission has familiarized him particularly with that section, and not because he does not realize that equally striking examples can be found in your own portion of the State.

Floods in Pennsylvania—It is perhaps not too much to say that the average person in Western Pennsylvania looks upon this great natural gift as a devastating engine of destruction, rather than as one of the greatest blessings. This feeling, founded on a constant repetition of loss of life and property, reaching its climax in the horrors of the Johnstown flood, may be said to have some foundation. Pittsburgh, alone, suffered $6,500,000 damage during three floods from March 15, 1907, to March 20, 1908, and $17,000,000 during the twenty years ending in 1907, and during that year the damage in the Ohio Valley was estimated at $100,000,000.

The Susquehanna Valley has suffered almost as much as have we in the Western part of the State. A careful estimate of the direct loss due to the four floods in 1889, 1894, 1902 and 1904, amounts on the West Branch to $13,000,000, Williamsport and Lock Haven being the principal sufferers; on the North Branch to $1,800,000; and on the Main River above the state line to $700,000 —a total for the basin of $16,500,000. You are, of course, familiar with the high water troubles in this section; and no doubt you recall the disastrous Passaic River floods of 1902 and 1903, causing a direct loss estimated at $10,000,000.

Variation of Flow—In spite of all these enormous quantities of water going to waste and leaving death and destruction in their wake, one finds these same streams a few months away with insufficient water for any useful purpose.

The comparative high and low water flows of certain streams in Pennsylvania are shown in Table I:

TABLE I

COMPARATIVE HIGH AND LOW FLOW RECORDS OF CERTAIN STREAMS IN PENNSYLVANIA

Name	*Station*	DISCHARGE (Sec. ft.)		
		Maximum	*Minimum*	*Ratio*
Shenango	Sharon	13,000	200	650
Kiskiminetas	Avonmore	80,000	65	1,200
Allegheny	Kittanning	245,000	850	290
Youghiogheny	Connellsville	62,000	20	3,100
Monongahela	Lock 4	207,000	160	1,300
North Branch, Sus.	Danville	305,000	820	370
West Branch, Sus.	Williamsport	164,000	410	400
Susquehanna	Harrisburg	700,000	2,300	300
Schuylkill	Fairmount	82,000	370	220
Delaware	Lambertville	250,000	1,200	210

Effects of Low Water—Navigation—The troubles due to these low stages are nearly as serious and costly, though not so spectacular, as those due to floods. The low water flow of the Monongahela River (160 cubic feet per second) is only about two-thirds of the quantity necessary to operate the present locks at their full capacity, even without making any allowance for losses by evaporation and leakage. Similarly, the Youghiogheny, the improvement of which, at an estimated cost of $1,000,000, has already been authorized, cannot supply enough water at extreme low stages to maintain pool-full navigation. Nor are all these difficulties in the future. With the exception of the Monongahela slack-water system, taken over and improved by the Government, all the old canals of Western Pennsylvania,—the Lake Erie and Ohio River Canal, the western section of the Pennsylvania Canal, theYoughiogheny canalization and others,—have been abandoned. A potent factor, in addition to the question of terminal facilities, and excessive maintenance cost due to flood damage has been the lack of sufficient water to operate the canals—while in every flood there has been going to waste enough water to operate many such waterways.

Acidity and Waste Disposal—The extreme conditions of alkalinity and acidity at these low stages are also a source of much trouble and expense. The difficulty of operating filtration plants on these streams is a byword in engineering circles, and excessive

expense for reagents is entailed in rapid filter and water-softening plants. The destruction of submerged metal structures and damage to boilers from extreme acidity are universally known. Such destruction manifests itself particularly at the low lock dams, where the acids, already strong because of low dilution, collect in still greater concentration because of their greater specific gravity. As a result, certain $\frac{3}{8}$ inch steel plates used on gates at Lock No. 2 on the Monongahela River were entirely consumed within two years.

FIG. 4. FILLING VALVE, LOCK NO. 2. MONONGAHELA RIVER.
Showing destruction by acid of steel plate $\frac{3}{4}$ inches thick.

The concentration of sewage at low stages of flow has greatly hastened the necessity of considering its treatment, and has brought he matter to its present acute stage in Pittsburgh, as is probably true here in Philadelphia, some years earlier than may otherwise have been necessary.

Water for Supply and Power—The difficulties of operating filters and softening plants have already been mentioned. But, in addition, the problem of available quantity is becoming more and more serious. The amount pumped from the Monongahela for industrial purposes is now about five times its minimum flow. That which is required for industrial and domestic purposes in Allegheny County is now about equal to the low water flow of the Allegheny River. It has been predicted that the Monongahela will soon be unfit as a source of domestic supply, and that the whole of the county will have to take its supply from the Allegheny River; so that, unless the low water flow of the Allegheny is increased, this alone may become a serious problem.

This day may, of course, be put off by reduction of the waste of water; for Pittsburgh, like some other cities, is shamefully extravagant in its waste of this valuable resource, and now supplies about 235 gallons per capita daily. It is a pleasure to report that at an election on November 4, the voters of that city approved a bond issue, $500,000 of which is to carry on metering. Nor have you lacked experience in Philadelphia with water waste, as is evidenced by the agitation and the splendid campaign of public education in favor of metering, that has been carried on by your Bureau of Water. Those of us who were interested in this important step in our own city recognized the similarity of conditions in Pittsburgh and in Philadelphia, and were only too glad to learn from your novel and valuable Water Waste Exhibit. All should recognize and acknowledge the help that has been given to the cause of water-waste-prevention, both in this State and throughout the country, by Director Cooke's well-carried out idea. While there can be no doubt of the effect of such good work, future growth may even yet cause the question of quantity available for water supply to be a serious one.

Many abandoned water powers throughout the State show the effect of low water on this important branch of water utilization. This most serious of water power problems—fluctuation of flow—has nowhere a greater effect than in Pennsylvania. You have in your end of the State, also abandoned canals and abandoned power sites.

Recommendations of Flood Commission

The Pittsburgh Flood Commission, originally appointed to report on methods of protecting the city from floods, soon found that it was impossible to consider the problem by itself. At every turn of its investigations, it met new phases of all the related problems of navigation, power, water supply, sewage-disposal, etc. Nor was it possible to avoid the state and national aspects of the question. The Flood Commission therefore adopted the policy of considering the relative value of all proposals on a basis, not only of flood protection for Pittsburgh, but of benefit of all kinds throughout the Allegheny, Monongahela and Ohio Valleys.

Fig. 5. Cheat River, West Virginia. Looking Upstream From Cooper's Gap.

Site of Reservoir No. 1, proposed by the Pittsburgh Flood Commission. This is one of the many excellent situations on the watersheds above Pittsburgh.

Effect of 17 Reservoirs—The Commission therefore recommended that 17 reservoirs* be constructed on the drainage areas of the

*Several additional sites were surveyed and many other possibilities exist, but seventeen are all that are needed for flood protection, only, and those chosen are of greatest relative effectiveness. It is well to know that other sites and additional capacity are to be found whenever needed for other purposes.

Allegheny and Monongahela to be supplemented by a river wharf wall along the low-lying portions of the Pittsburgh water front. The total estimated cost of these works was about $20,000,000. Their combined effect would be to protect the city from flood damage, even in case of a 40 foot flood—the highest previous stage being 35.5 feet.

Moreover, it was shown in the Flood Commission's Report that storage reservoirs for flood protection could be used for other purposes during a considerable portion of the year. During the past 38 years, about seventy-five per cent. of all floods at Pittsburgh have occurred between December first and April first. All of the remaining twenty-five per cent. have been comparatively small, and of short duration, and not one of them would have topped the proposed river wall, even with no allowance whatever for peak reduction by storage. It is apparent, therefore, that the reservoirs could be operated for other purposes during at least a great portion of the other eight months.

Increased Low Water Flow—Such operation of the seventeen proposed reservoirs would have increased the low water flow at Pittsburgh, throughout the dry season, to almost 3.5 times its present minimum, that of the Monongahela to about 6 times its minimum; that of the Youghiogheny to about 10 times its minimum; and that of the Ohio at Wheeling to about 3 times its minimum, increasing the stage 2.3 feet.

Such increased low water flows would prevent or greatly alleviate all of the present serious conditions that have been previously described. The imminent lack of sufficient water to operate the Monongahela locks at fully capacity would be permanently avoided. The proposed slack water system on the Youghiogheny would be assured of continuous, instead of intermittent operation. The number of locks and dams required to complete the slack water systems on the Allegheny and Ohio would be decreased, and the period of open navigation on both rivers lengthened.

The acidity of the Monongahela and Youghiogheny would be decreased by dilution at least fifty per cent. at extreme stages, and the present occasional acidity of the Allegheny could be prevented. The hardness of the Allegheny, the Monongahela and the Ohio for a considerable distance below Pittsburgh, would be reduce by about one-third at extreme stages. The quality of the rivers for water supply would be greatly improved, and the difficulty of

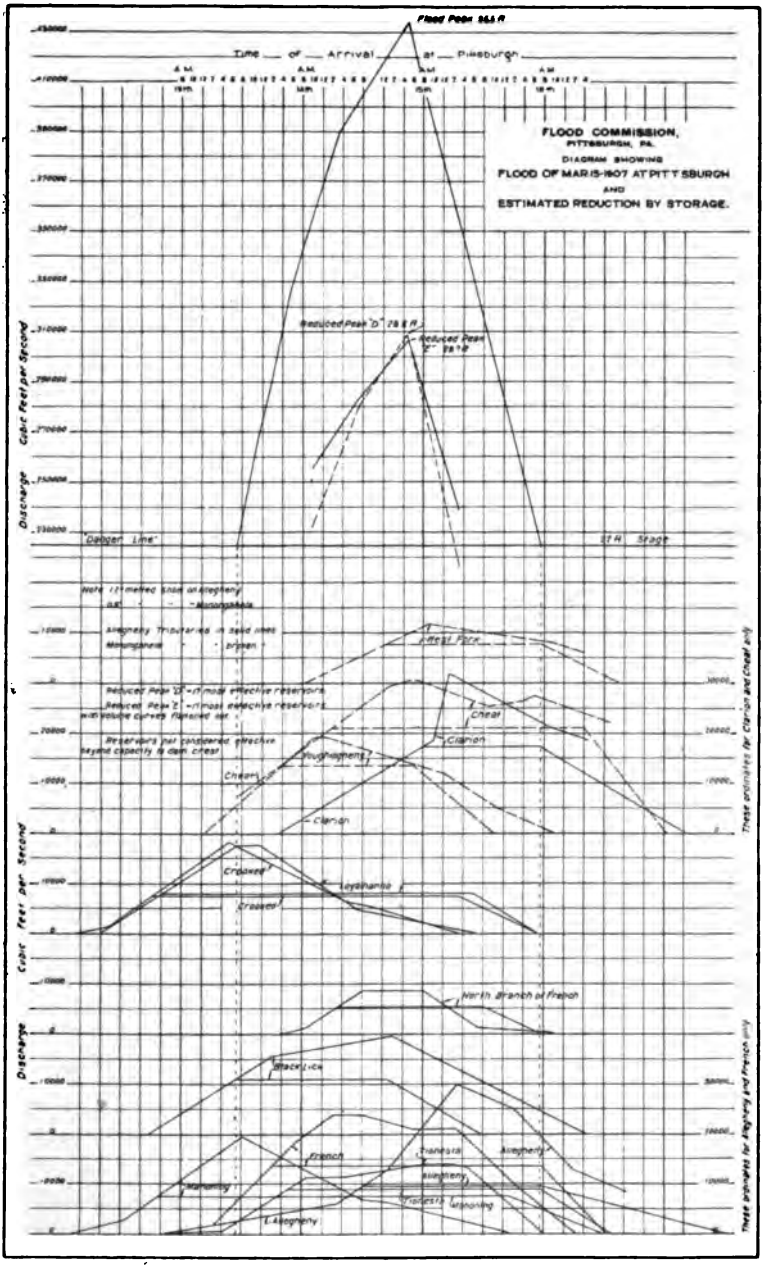


FIG. 6. DIAGRAM SHOWING FLOOD OF MARCH 15. 1907, AT PITTSBURGH AND ESTIMATED REDUCTION BY STORAGE.

Shows the effect obtained from the seventeen (17) selected and most effectiv e reservoirs. This is the highest recorded flood at Pittsburgh. Note that floods upon tributaries are non-effective at Pittsburgh unless their time-occurrence comes within the period when the Pittsburgh flood is above the danger line, or 22-foot stage.

filtration and the excessive expense for reagents would be materially reduced. The increased low water dilution of sewage would postpone the necessity for treatment, or simplify and lessen the cost of disposal plants. Finally, increased low water flow would benefit every power development on the stream below, and a large amount of power could be generated at the storage dams during the portion of the year when the reservoirs were not required to be empty for flood protection.

All of these advantages may just as readily be secured and appreciated upon your rivers of a similar character in the eastern part of the State.

Corroboration by Flood of 1912—Many of these deductions of the Pittsburgh Flood Commission were based in part on incomplete rainfall and stream-flow data, as the several drainage basins were not completely supplied with hydrographic stations during the floods that preceded the investigations of the Commission. In March, 1912, however, a flood occurred at a time when rainfall and river gauging stations were in operation on all the streams upon which reservoirs were recommended. Complete and accurate information was therefore available, and a study of these data was presented to the American Society of Civil Engineers by Mr. Kenneth C. Grant, Assistant Engineer of the Flood Commission, in a paper on "The Flood of March 22, 1912, at Pittsburgh."

It was shown here conclusively, by means of a peak reduction diagram, made up in the same manner as those in the original report, that the operation of the seventeen reservoirs would have reduced the peak at Pittsburgh from a gauge height of 28.1 feet, or 6.1 feet above danger line, to 16.9 feet, or 5.1 feet below danger line. This study is given particularly interest, also, by the fact that the flood of 1912 was caused mainly by the same streams that brought about the great flood of 1907—the Youghiogheny and the Kiskiminetas—though not in exactly the same proportion. In spite of the fact that the reservoir possibilities of these two watersheds are limited, the reservoirs proposed, considered as to effect in time and intensity and in combination with all the others, would nevertheless be effective.

The close correspondence of these results, based on actual measurements, with those of the report, necessarily based in part on assumptions, demonstrates the reasonableness of those assumptions, and justifies the Flood Commission's confidence in the value of the proposed projects.

Need of National and State Action

The work of the Flood Commission has been dwelt upon because it emphasizes so strongly the need of national and state action in working out this problem. This report, completed at a cost of $125,000, raised by local subscription, the most complete study of its kind ever made; and the first investigation of the merits of the sixty-year-old controversy, over the value of storage reservoirs based on actual surveys and careful estimates, yet demonstrates the futility of realizing our dream through local enterprise. Complete as it is, with respect to the kinds of benefits and those upon whom they would be conferred, it did not and could not attempt to determine the relative values of these benefits, when conflicting; to outline their equitable distribution among the beneficiaries, or to define a complete plan of water utilization as best serving the welfare of the Commonwealth. Still less is the Commission or the City of Pittsburgh a proper agent to furnish the funds for the entire enterprise proposed, or to supply the machinery for maintaining equity in the operation of the works when constructed. These are matters which cannot be handled in any other way than by the State; and their interrelation with the interests of the other States and of the Federal Government, affecting profoundly as they do, the navigation of our streams and the general welfare of the entire nation, render effective state action inconceivable without coöperation.

Newlands River Regulation Bill—Such coöperation will be made possible if, as the writer earnestly hopes, the coming session of Congress passes the excellent bill presented by Senator Newlands, of Nevada. This bill, as you know, proposes to appropriate $50,000,000 annually for ten years, to be used,—

"for the regulation of interstate commerce and in aid thereof for examinations and surveys and for the construction of engineering and other works and projects for the regulation and control of the flow of navigable rivers and their tributaries and source streams, and for the standardization of such flow, and for flood prevention and protection, by the establishment, construction, and maintenance of natural and artificial reservoirs for water storage and control, and by the protection of watersheds from denudation and erosion and from forest fires, and by the maintenance and extension of woodland and other protective cover thereon, and by the reclamation of swamp and overflow lands, and by the building of

drainage and irrigation works, and by doing all things necessary to provide for any and all beneficial uses of water that will contribute to its conservation or storage in the ground or in surface reservoirs as an aid to the regulation or control of the flow of rivers, and by acquiring, holding, using and transferring lands and any other property that may be needed for the aforesaid purposes, and by doing such other things as may be specified in this act or necessary to the accomplishment of the purposes thereof, and by securing the coöperation therein of States, municipalities, and other local agencies."

This fund is to be apportioned for expenditure to the following bureaus and services:

For the Smithsonian Institute	$ 1,000,000
For the Bureau of Plant Industry	2,000,000
For the Geological Survey	3,000,000
For the Reclamation Service	10,000,000
For the Forest Service (including $5,000,000 for the acquisition of forest lands by the National Forest Commission)	10,000,000
For the Corps of Engineers, U. S. Army	24,000,000

The complete investigations and formulation of the comprehensive plan of development provided for, and all construction works under the act, are to be subject to the consideration, advice and recommendation of a Board of River Regulation;"—consisting of the Chief of Engineers of the United States Army, the Director of the United States Geological Survey, the Forester of the Department of Agriculture, the Director of the Reclamation Service, the Chief of the Bureau of Plant Industry of the Department of Agriculture, the Secretary of the Smithsonian Institute, one civil engineer, one sanitary engineer, and one hydro-electric engineer,—the last three to be appointed by the President.

It seems somewhat unfortunate that the bill, and the able addresses in its support by its author, should so rigidly adhere to the old doctrine that river improvement can be undertaken by the government only in aid of navigation. This may have been considered a necessary political expedient at the time the bill was drawn; but we have progressed in political philosophy since then, and the time has come when we should firmly establish the principle that the Federal government has the authority and the duty, under the general welfare clause of the Constitution, to act in a

matter so vitally affecting the entire country, and requiring an expenditure and an organization which no state or states can provide. It is a strange anomaly that so thorough a progressive as Senator Newlands should fail to recognize that the general welfare is inseparably bound up with the water resources of the entire country, when so thoughtful a conservative as President Taft declares that flood protection in the lower part of the Mississippi Valley alone ought to be undertaken under the general welfare clause. In an address before the National Rivers and Harbors Congress at Washington, December 4, 1912, the President, speaking of the Mississippi floods, said:

"Now, gentlemen, I do not want to say anything invidious, but the hanging of the expenditure of $40,000,000 or $50,000,000 that will be necessary to make that river safe, on the improvement of navigation that is going to flow from that expenditure of $40,000,000 or $50,000,000 is a pretense. We might just as well face that right away. It is not necessary to spend $40,000,000 or $50,000,000 in order to make that a good waterway, but it is necessary to spend that amount if we are going to make that river so that it shall not be destructive to all that part of the country every few years. . . . . What you have to face, gentlemen, is this: Under the welfare clause of the Constitution, ... we have to meet the issue, Shall we spend for that great section of the country $40,000,000 or $50,000,000 in order to make the levees of that river a system which shall prevent the destruction which has aroused our deep interest and great pity for those who have been subjected to enormous losses in that part of the country? Under the Constitution, we can expend money from the Treasury of the United States for the general welfare and that would seem to include the avoidance of danger, if it affects so large a part of the country that it may be said to affect the whole country, and if its avoidance involves such large expenditure that we cannot possibly look to the State to meet the requirement."

The Newlands bill would provide a sum of money commensurate with the importance of the benefits it would obtain, and would supply the machinery, the lack of which would be an effective bar to satisfactory progress by any State. At a time when Pennsylvania is about to take important steps along these lines, as will be shown later, it is essential that its national representatives be made to understand unmistakably that their support is required of a measure, in which the interest of the State is so strongly involved as in this one. The writer hopes that the well understood

conservatism of the engineering profession will not prevent this and other engineering bodies throughout the State and country from studying and investigating the Newlands River Regulation Bill, or the members of such bodies from fulfilling their obligations as citizens and expressing their desires, which by the nature of their source, must demand in this case exceptional consideration from legislators.

Historical Sketch of the State's Part in Water Development in Pennsylvania

Although the conditions that exist in Pennsylvania are very far from the ideals we have pictured, it is nevertheless true that much attention has been given by the State, in an incomplete and disconnected way, to the development of its water resources, since early in its history.

As early as 1758, river improvement was taken up, and a passage effected for flat bottomed boats and log rafts through the rapids at Trenton Falls. In 1762, a petition was presented to the Assembly by a number of Philadelphia merchants, asking that the West Branch of the Susquehanna be improved so as to make possible communication by portage, with the Ohio River, but no action was taken. The American Philosophical Society took an important part in promoting canal construction and in 1769, under its auspices, a survey was made of a canal route to connect the Schuylkill with the Susquehanna. But no actual canal construction took place before the Revolution.

Early Canals—In 1797 the Conewago Canal, one and one-half miles long, on the Susquehanna River at York Haven, was completed by a private company. This was authorized by the State in 1793.

In 1826, the Legislature authorized the continuation of a private canal, which connected the Delaware and the Susquehanna, up the Susquehanna 54 miles to the Juniata. This was the first step in the development by the State of a comprehensive canal system—the first to be proposed by any State in the Union. This era lasted nearly forty years, and during that period about 600 miles of canals and river improvement in all portions of the state were completed.

At the same time, a great number of private canal companies were incorporated, and these canalized many streams in addition

FIG. 7. CANAL AT SHICKSHINNY, LUZERNE COUNTY.
One of the early canals of Pennsylvania.

Finally, however, all these old canals failed to earn sufficient income and passed one by one into the hands of the railroads and then into disuse. Of them all, the only ones operating today are the Lehigh and the Schuylkill (with its negligible traffic) and the open river traffic on the Delaware, Allegheny, Monongahela and Ohio Rivers, which have subsequently been improved by the federal government.

Early Legislation—The old Mill Dam Act of 1803 legalized the construction, by any riparian owner, of a dam, "for a mill or other water works" upon "any navigable stream of water, declared by law a public highway except the rivers Delaware, Lehigh and Schuylkill." The act of 1874, together with its supplement in 1889, authorized the incorporation of water and water power companies, with the right of eminent domain, and a strong impetus was given to water utilization by private capital. Abuses, against which the old acts failed to provide safeguards, however, led to the revocation in 1905, of the right of eminent domain for new companies as to waters and lands covered thereby and a consequent decline in private development has resulted.

The Water Supply Commission—At almost the same time, the Water Supply Commission of Pennsylvania was created by an act, which was the first attempt to attack the problem in any comprehensive way. The Commission was given, by this and supplementary acts, certain vaguely defined duties with regard to investigation and reporting on the condition of the water resources, and some authority over the incorporation, merger, sale and extension of water and water power companies, but none as to service and rates, although the Commission called attention to this need. In spite of the failure of the act to clearly define the duties and powers of the Commission, to authorize and working out of a comprehensive plan of development, or to appropriate sufficient money to carry out its purposes properly, the Commission has splendidly justified its existence. The act, however, has had time to demonstrate its imperfections and for the first time the errors of the past now stand plainly out, and the way is clear for genuinely progressive legislation in Pennsylvania.

The Guiding Principles

The history which has been outlined illustrates the incomplete conception of the magnitude and importance of the problem that has characterized the part played by the State at each stage. Three things stand out as necessary guiding principles of a successful state policy of water utilization, and one or more of these has been conspicuously absent from every previous State action.

1. Comprehensive Plan—Complete and thorough investigation of the water resources of the State, considering each stream as a unit and all of them as a whole, keeping in view all the uses to which they might be put and the requirements of every interested community, and considering the equities of this and all future generations; so that, so far as is humanly possible, use by this generation may be consistent with a maximum possible total benefit in all times;—such a broad-gauged study and consideration should be provided for as a step in the formulation of a comprehensive plan of development for the whole State, and the adoption and enforcement of a clear-cut definite policy for the utilization of water.

2. *State Regulation*—Adequate regulation by a State Commission, with ample well-defined authority, over incorporation, con-

struction, service, rates and accounting of all persons, companies, and municipalities utilizing water for public use, or in such a way as to affect this plan, is essential to allow the enforcement of the policy; in order to prevent a repetition of the abuses that led to the recall of the right of eminent domain in 1905, and to protect the State and the people from exploitation in rates or service.

3. Encouragement of Private Enterprise—Until the State is in a better position to undertake the construction and operation of the works necessary to utilize the water resources, and so long as the political and economic philosophy upon which our social organization is now based prevails, it will be necessary and desirable to permit and encourage private enterprise in these fields. This is particularly true in Pennsylvania, where the Constitution prohibits the creation of any debt except, "to supply casual deficiencies in revenue, repel invasions, suppress insurrection, defend the State in war, or to pay existing debt." Works of sufficient magnitude and comprehensiveness cannot be financed out of current revenue, and at least three years' delay for a constitutional amendment would be necessary if the State is to be looked to for relief.

This principle of private development, under governmental regulation has been ably endorsed as a basis for a national water power policy, by Secretary Fisher, in his annual report to the President, dated December 3, 1912, as follows:

"Our present economic and social institutions are based upon the theory that the welfare of the community is to be promoted largely through the opportunities of personal gain offered to individual members of the community. It is through these opportunities of personal advantage that we expect to stimulate the ambition and the energies of private individuals whose activities in the mass promote the welfare of the community and advance the prosperity and the happiness of the people as a whole.

"So far as government itself does not undertake the development of water power it is therefore necessary and desirable that we shall offer to those private interests which do undertake its development a sufficient opportunity for profit and a sufficient protection of their investment to secure the largest measure of development for which there is a present market, or for which a market can profitably be developed."

These ideas are also in thorough accord with the Water Power policy of the National Conservation Association, as is indicated by the following extracts:

"Power sites should be developed, not held unused for speculative purposes. . . . Cheap, and partial development for large and quick profits should not take place, so as to prevent full development for moderate profits. . . .

"Every stream is a unit from source to mouth. It should be applied to human needs . . . . in such order of preference or in such combination as will be of greatest public benefit.

"Private enterprise is not self-sufficient . . . Public aid is needed in one or more of the following ways; . . . Authority to use pr vate lands . . . and private water rights . . . . without the owner's consent (eminent domain) . . . . authority to assess the cost of water storage upon the lands specially benefited thereby. All power sites below the reservoir are so benefited.

". . . . Water companies may rightfully demand certainty of tenure; . . . . adjudication of differences by an impartial tribunal; . . . . a fair chance for a generous profit on the investment; . . . fair compensation for permanent works taken from the company at the expiration of its franchise, privilege or lease."

There is nothing about them inconsistent with the "Ten Commandments" of the Pennsylvania Conservation Association, from which the following quotations are taken:

"*4. Watercourses as a State Resource.* The waters of the State are one of the most important assets. They should be systematically mapped and considered, and eventually developed and utilized for the equal benefit of all citizens. In such development every stream should be considered as a unit, from its source to its mouth. . . . .

"*5. Supervision of Use of Waters by Corporations.* Private projects for water power development seeking State aid in the form of a corporate franchise, carrying the right to condemn property, to use lands or water rights belonging to the public, to obstruct navigable rivers, or otherwise, should be subject to careful consideration and to strict regulation, in order to secure prompt, complete and orderly development; efficient service at fair prices and on equal terms to all consumers in like conditions; full public information as to costs and profits; honest capitalization on a basis of cost; and fair rentals for public property used within the franchise granted. . . . ."

Progressive Legislation in other States

These principles have been recognized and to an extent adopted into legislation in some other States, leaving Pennsylvania behind in the procession. The Western States—Oregon, Washington,

California, Idaho, Colorado, and others—have been attempting to work out the problem for several years, and have taken advantage of the conditions peculiar to their section to establish in their Constitutions or laws the public ownership of all waters and the right of prior appropriation for beneficial use, an example impracticable of emulation in the East. Some of these States, also, have developed efficient administrative systems under these laws;—notably in the case of Oregon.

Wisconsin, always progressive, passed a complete act embodying these principles in a system of water laws in 1910, but the bill was apparently drawn without due consideration of constitutional limitations and was properly set aside by the Supreme Court of Wisconsin, in 1911.

New York, Maine and a few other Eastern States have also passed or have under consideration excellent legislation on the subject, but in no case east or west has the problem been grasped in its entirety; and in no case have all the fundamentals been wholly included in legislation. Pennsylvania, though some distance in the rear, has an unequalled opportunity to take at a bound its rightful place as leader of the States in this field of progress.

History in the Making in Pennsylvania

That Pennsylvania is going to take advantage of this opportunity is strongly indicated by recent events in the State.

Pittsburgh Flood Commission's Activities—The Flood Commission was led by its studies to a recognition of the essential requirements of a State water policy, and to an appreciation of how far conditions in the State fell short of those requirements. It was for these reasons that this Commission presented to the Water Supply Commission on October 4, 1911, its argument against the granting of any further water power charters, until it could be certain that there would be no conflict with the highest public interest. For the same reasons, the Water Supply Commission gave serious consideration for some 18 months to this important subject, and finally granted only two out of the number under consideration, and though the extent of its authority may be uncertain, attached to these, stringent conditions and restrictions, among which are the following:

"Second—That within twelve months after date of issuance of Letters-Patent, there shall be presented to the Water Supply Commission of Pennsylvania the following data:

(*a*) "An accurate map of the area flooded by each dam, with contours sufficient to calculate the quantity of water impounded at various depths, also reviewed data concerning rainfall, run-off, available storage and the effect upon them of drought or freshet conditions: Also the extent to which the reservoirs formed can be used to ameliorate floods in the Clarion and Allegheny Rivers . .

"Sixth—That the operation of reservoirs, in so far as the control of floods and the maintenance of low water flow is concerned, shall be subject to the direction and jurisdiction of the Water Supply Commission of Pennsylvania."

Republican and Democratic Platforms—The growth of these ideas, and the excellent project of progress, are further indicated by the fact that the controlling party in the Legislature is pledged to comprehensive legislation on water problems. The party platform promised an effective public utility law, and further, with respect to water legislation, said:

"Particularly do we deem it advisable for the State of Pennsylvania to take a firm grasp upon its water problems. Transportation, flood prevention, reclamation, sewerage, water power, and other incidents of stream flow are questions of extreme importance to the Commonwealth. While these questions present different aspects from the national, the state, and the municipal viewpoints, their solution cannot be adequately and efficiently effected except by some plan of harmonious and coöperative action, ...

"We pledge the enactment of laws permitting and providing for joint action and joint contribution of funds for these purposes."

The Democratic convention also pledged itself to enact a public utility law, and, according to State Chairman George W. Guthrie, the following water plank was approved by the Platform Committee, and would have been included in the platform had it not been omitted, by a clerical error, in transcribing their report.

"We commend the special studies of flood conditions such as that recently concluded in the western part of the State, and urge the enactment of legislation carrying into effect the recommendations that have been made for the control of floods, for increasing the navigable flow of rivers, for the development of water power, and for bettering the sanitary conditions of our rivers. We advocate the coöperation of the State of Pennsylvania with the counties of the State and with the national government in the construction of storage reservoirs and other works to carry the above outlined benefits into effect, believing that these are matters in which the state is vitally interested."

The Pennsylvania Water Utilization Association—The importance of the promised legislation to the people of the State and to capitalists seeking opportunities for investment led to the belief that a special organization was needed to make certain that such legislation should be sufficiently comprehensive and include all of the fundamental principles that have been worked out. This was the reason for the formation of the Pennsylvania Water Utilization Association, of which the writer has the honor to be President. Its purposes and membership may be made plain by repeating certain extracts from its by-laws, which are as follows:

"*Article 2. Object*—The object of this Association shall be to obtain, by publicity, conference and otherwise, coöperation of individuals, associations and companies interested in water conservation, to secure adequate legislation under wise State supervision necessary to the broadest and best utilization of the waters of the State.

"*Article 3. Members*—All membership shall be personal, and representative as far as possible of all the various water concerns, civic organizations, engineering societies, flood protection committees, and all others interested in these questions."

The plan of campaign has consisted in seeking the coöperation of all interested companies, associations and publicists promoting local agitation and studies along the lines of the stream-flow and flood prevention; and of the intensive study of water legislation in this and other states and countries, with a view to advocating a system of water laws suited to the needs of Pennsylvania.

Legislation Required

It was at first intended to draft a suggested complete code of water laws; but the excellent work of the Republican Legislative Committee, the intention of the Water Supply Commission to draft legislation, and the activity of the Pittsburgh Flood Commission may make that wholly unnecessary. It now seems probable that it will be requisite only to assist by discussion and criticism, and to support suitable legislation presented by others.

Proposed Public Service Bill—The Republican Legislative Committee has made public a tentative draft of a Public Service Commission Bill, with which many of you are no doubt familiar. We have suggested some additions, so as to include within the jurisdiction of the Commission, possible companies or associations,

formed solely for storage and stream regulation; also, to allow the reasonable charges of such companies or associations to be assessed by the Public Service Commission on water users who are benefited thereby, in connection with their use of water. These suggestions may even now be somewhat in advance of the general thought of the day, but yet they are fundamentally correct, and we consider them most desirable, in order to encourage stream regulation by private enterprise, and to make possible the organization of such associations as the "Genossenschafts" of Europe. On the whole, the bill as drafted is an excellent one, and should have the hearty support of all who are interested in the best development of the resources and of public service.

It is a drastic bill, but perhaps no more so than necessary to insure that the public utilities shall perform their obligations, and to protect the people from abuse and exploitation, in rates or service. It accords with the belief of our Association, that the enforcement of a comprehensive policy of water development is probably impossible, without thorough-going state regulation by an authoritative Commission, and provision to encourage private enterprise and to insure to utilities a life free from competition and harassment.

Proposed Incorporation Bill—It has been stated in the "Foreword" of the "Tentative Draft of a Public Service Commission Bill," that the Republican Legislative Committee "had, however, directed the drafting of an act dealing with the incorporation of public utilities." We have suggested that such a bill should provide definitely, that the issue of letters patent, and approval of merger, sale, or extension of charter of any company, making use of water resources, should be subject to the approval of the Water Supply Commission and to such conditions, restrictions or changes as they may consider proper: that no such approval should be given in any case, without acceptance of the provisions of the Public Service Act, such Incorporation Act, and the new Water Supply Commission Act; that public utilities should be given the power to appropriate private property and rights for public use, subject to the permission of the Public Service Commission, and, in the case of water companies of all classes and of the appropriation of waters, subject also to the permission and restrictions and regulations of the Water Supply Commission. We also recommend ample substantive powers, as to the right to construct and

operate works, for the development of all the water resources of the State, subject to the same regulative supervision.

If such a bill is drawn with the same breadth of view and the same fairness to both companies and people as the Public Service Commission Act, and if it contains the important provision that we have suggested, it will receive our support as essential to the encouragement and proper control of private enterprise.

New Water Supply Commission Legislation—We hope that the Water Supply Commission will present comprehensive legislation enlarging and defining its duties and powers to the extent that is needed, and we will be glad to assist in its preparation and to give it our support. Some of the ideas which we believe should be included in such legislation, or which perhaps may some day become part of the machinery for a State Department of Public Works, are briefly outlined below:

"It should be plainly stated that the jurisdiction of the Water Supply Commission extends to all the public or navigable streams and streams that have been declared public highways, in the State, or between this and other States; and to all tributary streams, whenever the latter or any of the waters thereof may be used for any public purpose, in a way to effect any of the purposes of this Act.

"The Commission should be authorized and required to collect and publish complete information about the water resources of the State and about opportunities for development, and to formulate a comprehensive plan and adopt a definite policy for the complete development and utilization of the water resources of the State.

"No construction, extension, or improvement of works for the utilization of water, or affecting the water policy of the Commission, should be allowed without a permit from the Commission.

"The Commission should be authorized to determine the benefits received by water users from storage on the stream above, and to certify the facts to the Public Service Commission, as a basis for assessment of reasonable charges.

"The Commission should have authority to require reservoirs to have such additional peak flood storage capacity and facilities for increasing low water flow, as is required by their water policy; and to enforce such regulations regarding the operation and joint use of reservoirs for various purposes as seems best.

"The Commission should have supervisory control of the design and construction of all dams, reservoirs and other works, and should investigate existing works and should have authority to require such changes as public safety and public welfare may demand."

In addition, the Flood Commission is proposing to ask for a State appropriation to construct a reservoir or reservoirs on rivers on the Ohio Basin. This bill will have our hearty support, and we believe the commission should be given authority to construct and operate such reservoirs, whenever any such appropriation is made.

It is apparent that there may be difficulty in preventing conflict and duplication in the performance of the functions assigned in these bills to the Public Service and Water Supply Commissions—it may eventually be wise to consolidate the two commissions so far as their duties refer to supervision of private companies, and to reserve the Water Supply Commission's functions of study, construction and operation, possibly, to a State Public Works Department. For the present, however, it seems advisable to continue the separate existence of the Water Supply Commission, so as to make use of the organization it has built up, and to leave this future condition to be reached by evolution.

Opposition Anticipated

The position of the writer and of the Water Utilization Association, and the character of the proposed legislation have been dwelt upon at some length, because it is important that you should understand them in considering the opposition that has developed and that will continue. This opposition has at times manifested a tendency toward invective and a lack of charity that has made difficult the calm consideration that so important public interests deserve.

Opposition to Private Development—This tendency has been particularly marked in the case of those who declare themselves unalterably opposed to any development by private capital. Such persons appear unable to conceive that some capitalists, and some of those who associate with them, are honest in their intentions, or that any means can be found to prevent oppression and piracy by grasping plutocrats, if private enterprise is permitted to undertake development. How the adherents of this doctrine, so out of tune with that of accepted regulation, and so thoroughly inconsistent with our entire economic and social organization, as shown in the report of Secretary Fisher, previously quoted, escape advocating state socialism for all industry, is difficult to understand. It is particularly remarkable that some of them should be found in the

ranks of the Pennsylvania Conservation Association, the "Ten Commandments" of which, as well as the policies of the parent National Association, are so thoroughly in accord with the ideas embodied in the proposed legislation.

Any reasonable consideration of the proposed laws previously outlined must overthrow the claimed contention that there is no intention to protect the public as well as the companies. A powerful Public Service Commission, with complete authority over rates and service; a virile Water Supply Commission, with complete authority over design, construction and operation; an Incorporation Act, requiring the approval of two commissions on the chartering of or the exercise of eminent domain by any water company;—if these are not sufficient protection for the public, then nothing can be and the reactionaries are right. Private capital must be put out of business! But if experience and history mean anything, this comprehensive combination of well tried expedients will leave no ground for this kind of opposition.

Opposition of Local Land-owners—There is certain to be opposition, also, by farmers, land-owners, railroads and other interested parties who foresee that the utilization of water by storage means the taking of lands and rights of way, and limitation of railroad extension by the prohibition of location on reservoir sites. But the principle that private property is held subject to the right of the sovereign State, or its authorized agent, to take it for public use, in payment of just compensation, is too firmly established to be attacked by interested parties at this date. The proposed bills provide ample control and supervision, so that there need be little fear that property will be taken except in the public interest, before which private interest must give way.

Nor is there ground for the fear that compensation will be inadequate. Democratic governments have always been particularly concerned to protect the individual in cases of eminent domain, and it is true now, as it has always been, that the error, if any, is likely to be on the side of extra liberality. It is for this reason that the Constitution prohibits the Legislature "from depriving any person of an appeal from any preliminary assessment of damages," and guarantees the right to have damages "determined by a jury, according to the course of common law." It was for the same reason that the Massachusetts act, authorizing the construction of the Wachusetts Reservoir, provided, not only liberal com-

pensation for property taken or injured, but also payment of damages to store-keepers who, though losing no property, lost business because of the removal of many of their customers from the locality. The New York water supply act contained a similar provision, and provided further that any person employed in any established business or manufacturing establishment, which was injured or destroyed by the taking of land, might recover from the city damages, not exceeding the wages or salary paid to such person during the preceding six months.

So, also, for the same reason, the property owner in this State may feel assured that his rights, in this respect, will be jealously guarded by the Commission charged with the duty of awarding damages, and by the jury if he appeals.

Fear of Disaster—Finally, there will be opposition to any and every project involving storage, from dwellers on the stream below, who have come to look upon dams and disasters as synonymous. Nor is this surprising in our State, which has suffered so grievously from dam failures. Yet, is it too much to ask such opponents to apply to this matter the same reason and common sense that they use in the other affairs of life, and not to condemn entirely a proposal, so strongly calculated to promote public welfare, because of failures, however disastrous, due to improper design or construction, lack of adequate supervision, or some other preventable cause? How much better to seek to devise means of preventing these causes, and to make use of this, as we do of other means that man has devised to harness for his benefit the forces of nature!

What would become of our boasted civilization, if we consistently adopted this policy of giving up? We would long ago have abolished the railroads that claim every year more victims than did the Johnstown flood. Bridges would have been prohibited after the failure at Quebec. Steam-ships could not be built because the Titanic went down. Automobiles would be abandoned, and elevators tabooed. Steam boilers would have to be given up to prevent explosions and the use of electricity could not be defended for a moment. Is there any one of the conveniences that make life today more comfortable and more satisfying than it was a thousand years ago that could survive the test by this criterion of the dam fearers?

This is not the Anglo-Saxon, it is not the American way of doing things. Moreover, it is particularly unjustifiable because

the preventable causes and the means of obviating them are so clear. Engineering skill has built dams that have not failed. For proof look at the hundreds that make possible the supply of water to our great cities, or at the magnificent monuments of the United States Reclamation Service in the West. Engineering skill can still build dams that will not fail. The State must see to it that it does so. A higher standard of requirement for engineering practice set by a system of licensing may help greatly. But still more important is it that the State shall, through competent engineers of its own, examine designs and inspect construction of dams, and investigate existing structures; and that it should give to some Commission authority to make and rigidly enforce the requirements of change in design or construction, or of alteration of existing structures, that public safety may demand.

This the proposed Water Supply Commission legislation will do. A Commission with the powers as suggested, with any reasonable efficiency, would have prevented the Johnstown flood; with any efficiency whatever, it would have prevented the Austin disaster from following the failure of the dam eighteen months before.

"But, we may have an inefficient Commission and careless inspectors," some one objects. True,—no system can ever take the place of good men in anything. Also we may have inefficient governors, and dishonest legislators, and grafting councilmen. And yet we will cling to the idea that government is better than anarchy, and try to do our share to better conditions and to see that good men are put in office. And just so we are going to attach the problem of regulating dam construction, and we are not going to give up until we succeed in making these desirable structures as safe as they are useful.

An Appeal for Progress

We have seen now what the problem is. We have caught a glimpse of the wealth and comfort and prosperity that will follow its successful solution. We have sketched the measures that are proposed and considered in advance some of the opposition to be expected. What are we going to do about it?

If the writer has succeeded in bringing the matter home to you, if he has stimulated your interest and aroused you to consideration and discussion, he will feel that he has performed a substantial service for the cause of conservation. For your consideration

and discussion will bring about improvements in the proposed laws, settle the arguments of their opponents, and, by disclosing the opinion of a body of citizens peculiarly qualified, by training, experience and habits of mind to judge of these matters, make an important contribution to the prospect of progressive action by the Legislature.

DISCUSSION

JOHN C. TRAUTWINE, JR.—Nearly four years ago, I had the audacity to present, before this Club, a little but highly heretical paper entitled "Socialism, as Illustrated by Papers Recently Presented to The Engineer's Club of Philadelphia;" and, last fall, at the Washington convention of the New England Water Works Association, I had the good fortune to hear a part of Mr. Knowles's paper on Public Utilities and learned that he is as good a socialist as any of us. I was therefore prepared to hear something of interest this evening, but I scarcely expected to hear the praises of socialism sounded so heartily, and its inevitability and its beneficence set forth so convincingly, as to throw my modest effort completely into the shade.

Mr. Knowles, however, through his contact with the politicians of the western end of the State, seems to have learned enough of practical wisdom to suppress almost wholly the use of the odious *word*, "socialism," while describing the *thing itself* in terms which must have converted the most case-hardened individualist—of course without his knowing it.

I say "*almost* wholly," for Mr. Knowles did once mention the *word*, namely: when he remarked that certain ultra-socialists protested against permitting water-powers to be controlled by what we call "private enterprise." Here Mr. Knowles asked, in effect, why then the protestators should not favor complete state socialism. But, while he asked the question, it is significant that he refrained from suggesting an answer.

No one quarrels with the State for furnishing us with water, gas, streets, parks, schools, police and fire protection, postal and railroad facilities, and, in short, with all that distinguishes civilization from savagery. Why, then, may it not furnish also food, clothing and shelter generally, as it does in the Canal Zone? The answer is easy: Because we have not yet become accustomed to its doing so.

The objectors to private control of water-power privileges, as a temporary expedient, would seem to be short-sighted. The corporation, operating a water-power, is as truly the State's agent as though it were paid a salary, instead of being permitted (as at present) to maintain a fiction of "ownership" and to find its reward in the profits which it can extort from its masters.

And these objectors seem to be blinded by the admitted evils perpetrated by some of these corporate agents, so that they fail to see the prodigious service which these agents have rendered to the community, not only by undertaking and carrying on public works during the adolescence of the state, but (far more important) by thus educating us all (for the most part unconsciously) to the enormous advantages of the socialistic method; so that now, when the State (by the increasing restrictions, which it places upon the corporations), is surely and rapidly confiscating their property and their franchises, and converting us

all into an army of public employees, we are found not only acquiescent, but, in general, unaware that any such work is in progress.

That it is in progress is manifested by the eagerness with which professional politicians are tumbling over each other in their zeal to be found in the "progressive" camp. With their characteristic low cunning, they have "seen which way the procession is going," and they are making haste to "get in front."

In the early days of some of us, yet living, business was mostly carried on by individuals and firms, with numerous small corporations running our numerous small railroads. As to governmental business, we had become accustomed to it in the form of national and coast surveys and harbor improvements, and even in water supply and sewerage; but, for the most part, we were content to mumble Emerson's nineteenth-century formula that the least government was the best.

Today, public problems have increased so enormously in difficulty, in number, in importance and in complexity, and they have become (as Mr. Knowles has said) so intimately inter-related, that even our conservatives are beginning to wonder whether certain functions, hitherto exercised by our cities, must not, some day, be placed in the hands of the state or the nation. President-elect Wilson lately said: "The question of sewage affects whole sections of the state. It cannot be dealt with community by community, without regard to the topography of the country, the method and closeless of its settlement or the natural facilities for the disposing of sewage;" and our Massachusetts brethren, with characteristic progressiveness, have set us the example of a Metropolitan Water and Sewerage Board, controlling jointly the service of many neighboring communities

The railroad and the telegraph (in its several forms) have made our entire country smaller today than was the State of Pennsylvania a century ago, and our separate State governments have become anachronisms, blocking, rather than urging, the wheels of progress; as have also our old-fashioned State lines, following a meridian or a parallel over hill and dale; and I venture the prediction that the next half-century will see the abolition of our state governments, as they exist today, the division of the country (for convenience, not for politics) into its greater and lesser water-sheds, which will take the places of the present "States," and the control of the water supplies of the nation or of the world, concentrated in a central national or international office, which shall command the united and organized services of all the greatest hydraulic engineers; whereas, now, the small community (though made up of persons whose lives are presumably almost as valuable as our own) must put up with the services of engineering bodies, made up of an insufficient number of men of at best inferior professional rank.

Mr. Knowles's remark, at the opening of his paper, respecting our water supply as an item of transcending wealth, was particularly timely. Thanks to an ancestry reaching back to the beginning and always under the bane of individualism, we come into the world with the curious notion that "wealth" consists in the few pennies which a Morgan or a Rockefeller, or one of us, can accumulate and which, if he chooses, he can fence about for his exclusive use; and our environment rubs this notion into us, from the cradle to the grave.

A man without money is considered "poor," although he (equally with the multi-millionaires just named) is the virtual owner of all the streets and parks in the civilized world, although he may have all the water he wants, supplied

to him by the community as a whole. It is well that we should be reminded of the absurdity of such notions; for it is they which, more than anything else, retard our progress toward civilization. Owners of "property" (really tax-collectors, though calling themselves "tax-*payers*") oppose every effort to increase their real wealth by means of drafts upon their private or fictitious wealth; and we may be sure that Mr. Knowles's proposed scheme of river regulation for the Pittsburgh district, will not be put through without encountering their lively opposition, although its construction costing, if I remember rightly, not much more than the mischief wrought by one severe flood, will eliminate all future floods. Such is the wisdom of our wise men!

Mr. Knowles was disposed to admit that this dream of a worthy conservation of our water-sources was impossible of realization. If he will qualify this by adding "within the next few years," I must reluctantly agree with him. It is a law of social, as of physical, mechanics, that the movements of great masses cannot be suddenly and greatly changed without risk of damage somewhere. Any attempt to grasp the blessing prematurely could result only in lamentable failure; but the change is coming about, quite as quickly as our conservative natures can stand it; and any one who, in imagination, will glance along the curve of our progress in this direction during the last hundred, fifty, twenty-five, ten, two years, must recognize the stupendousness of the change already accomplished, and must see that its complete realization, during the lives of some now living, is as inevitable as its immediate accomplishment is impossible.

PAPER NO. 1124

THE ENGINEER'S INTEREST IN PUBLIC LAND QUESTIONS.

BY GEO. OTIS SMITH.
Director, United States Geological Survey.

Read January 18, 1913.

The public land problem of today relates to approximately one-third of a billion acres of unappropriated and unreserved lands in the United States and a similar areage in Alaska, together with some three hundred million acres of National Forests, parks, and other reserves. That is the size of Uncle Sam's real estate holding in 1913. Fifty years ago it was much larger, though perhaps possessing no greater market value. During the half century from 1803 to 1853 the United States of America acquired lands to the extent of one and a third billion acres, another one-third of a billion acres in Alaska constituting a subsequent purchase. With this embarassing wealth of lands, the Federal Government naturally endeavored in the following half century to dispose of its vast domain, and the problem was largely that of getting pioneers to penetrate the wilderness. Land grants were made to the newly organized States, to the transcontinental railroads, and to builders of military wagon roads on a scale that now seems lavish, and in amounts that aggregated hundreds of millions of acres.

The earlier policy of sales logically gave place to that of settlement laws, the purpose and principle of which were the establishment of homes upon the land, the distribution of the Nation's lands among its citizens, and the creation of a class of home-owners. So, too, with the mineral lands, discovery and development were the only statutory conditions imposed by Congress as preliminary to transfer of title for the richest of mineral treasure. Thus the nineteenth century, which saw the creation of a national domain, an empire in itself, also witnessed the distribution of more than one-half of its area.

The alienation of so large a part of the nation's land is not wholly a matter of regret. The winning of the West necessitated terms of land transfer that today may seem far too generous. The fact that must not be overlooked, both as we judge the past and plan for the future, is that conditions have changed. The shrinkage of the national domain has naturally been coincident with the Nation's development in all lines of industry. The Western prairie has become the world's granary, and what were once public lands are contributing to their private and corporate owners no small proportion of the world's output of metals and of mineral fuels. With the national growth on this scale, there has come necessarily a general increase in land values and the problem of finding land for the settler is already looming large on the horizon. Exploration and exploitation must now be followed by intensive utilization. With the most and the best of the Nation's land already alienated, the task is to put to its best use what remains.

Engineering in its broadest sense stands for increased efficiency and wise utilization. The engineer's relation to the public lands and the nation's resources is simply that of a constructive interest in their best utilization. The public land problem of today, whether we view it from the standpoint of a Federal officer or of a private engineer, is one of administration and of legislation. Your interest like mine in the matter is to have the existing public land statutes wisely and fairly administered and to secure the enactment of other laws that recognize present day needs. To enable your engineers to do your part in securing the highest use of the great resources now in public ownership, you need and deserve definite and prompt administration of the public lands—administration that is not a paper administration, but one based upon consideration of the same physical facts that you must determine and coördinate in your plans for development and use. So too, our interest as American citizens, you as the technical adviser of Capital and its active representatives in the great projects for industrial progress and others of us as the technical advisers of the Nation's executive and the people's representatives, in these same plans for national development, should lead us to unite in securing legislation adapted to promote the wisest use of the nation's resources. In the widest sense our interests are the same, because our purpose should be identical, the greatest industrial development of the country, but a development that will promote citizenhip as well as turn the wheels of industry.

By way of broadly outlining the public land problem of the present moment, I will mention some of the specific public land questions that concern the mining engineer, the railroad engineer, the irrigation engineer, the water-power engineer, and the municipal engineer. There are federal laws controlling the present disposition of western lands that are of vital concern to the engineering enterprises of various types represented in the work of your profession. Moreover, one and the same statute may affect projects of quite different type, but closely related by reason of the complex industrial conditions of today. Thus, the mining engineer is interested not only in the adequacy of the ore deposit, but also in the availability of power, timber, and water supplies; the irrigation engineer in his estimate of land values, which will warrant high construction costs, often must consider also proximity and permanence of mining camp markets; and the water-power and railroad engineers are both concerned in every factor affecting general development of the region which thus furnish or limit the market for power and the source of freight. In brief, the problem is one, big and complex, and the engineer who seeks to promote development on the national domain, and likewise the executive officer who administers the laws controlling that development, need to have brought to their tasks a realization of that complexity inherent in the problem. Even where the statutes are reasonably adequate, the same physical factors must be recognized by both engineer and federal officer and they should both be guided by similar regard for the stern requirements of economic law. On the other hand where the specific law affecting the proposed development is hopelessly archaic and inadequate, the engineer needs to understand that the public servant, no matter how high his official station, may be granted under this law absolutely no discretionary powers and therefore no opportunity to coöperate with the practical man in adopting the plain, common-sense solution of the problem.

If we agree upon highest and most beneficial use as the ideal sought by the engineer, land-classification becomes the first duty in public land administration. In a large way your interests as engineers and as citizens are identical, and the administrative officer's duty to you in your professional capacity and to the people as a whole is the same, namely, to decide every question arising in the administration of the public lands with full regard for the

physical conditions giving value to those lands and controlling their highest utilization.

Not only is the engineer interested in the right classification of land in order that he may not be an accessory or instrument of fraudulent practice, but he does not want to be connected with an engineering project that involves large economic waste. Your professional code opposes your contributing your technical skill to a mining development or an irrigation scheme, or a hydro-electric installation whose only possible purpose is the taking of a promoter's profits before that day of reckoning when the balance is struck between cost and value. Therefore, you and I are alike interested in knowing the facts of land-classification that will prevent the construction of reservoirs and canals for a Carey Act project where the water supply is insufficient or the soil unsuited to irrigation. We will agree that power-sites should be used as such and not as homesteads; that mineral lands should be acquired by mining men for mine-development and not by non-resident capitalists for the timber value; that irrigable lands should be irrigated and not dry-farmed; and that reservoir sites should be used to promote irrigation or power development, and not as cattle ranches.

The need of a definite and reliable classification of the public lands is self-evident, and the recognition of its value is no recent discovery, yet only within the past few years has scientific classification of our public lands been given a definite place in the administration of the national domain. It is true that in 1879, "classification of the public lands" was made the first of the statutory functions of the United States Geological Survey then created; but this duty was for over twenty-five years subordinated to the general task of investigating the public domain and its resources. Again in 1888, the Director of the same federal service was entrusted with the segregation of the irrigable lands and the selection of reservoir sites, but this irrigation survey later narrowed itself into the specific work of the Reclamation Service under the Reclamation Act of 1902, while the functions of stream measurement and investigation of water resources continued by the Geological Survey only very recently began to be recognized as a necessary basis for public land classification and administration.

The present system of land-classification, its contribution to public land administration, and its relation to the engineering

profession can perhaps best be indicated by specific though brief reference to the various federal laws which the several kinds of engineers may be obliged to consider in their plans to utilize the resources on public lands.

The mining engineer first of all encounters indefinite and inadequate mining laws, perplexing and unsatisfactory alike to himself and to the administrative officer. Here is the opportunity for coöperation in the crusade for legislation that will at least recognize the past one-third of a century's progress in mining engineering, geology and metallurgy. Pending such legislation, which needs to be framed to meet modern conditions in the mineral industry, the Chief Executive, acting upon specific recommendations of the Geological Survey, is making withdrawals of public lands whose chief value is for oil or gas, phosphate, and potash. There is no business wisdom in allowing oil lands to be longer located and explored under a law framed to meet the conditions of discovering placer gold. In the development of an oil field that law provides no protection of the purposeful prospector against unscrupulous claim jumpers, nor of the developer, well equipped with engineering experience and necessary capital, from the hold-ups of black-mailing paper-locators. Again viewed from the standpoint of the citizens generally, the federal landlord receives nothing from these rich lands although commonly the operator pays tribute to a middleman, usually larger in amount, and often with more exacting conditions than would be asked under a Federal lease. Similarly in the case of the mineral fertilizers, it seems plausible that a lease law can be framed with the help of the engineering profession, that will protect the consumer especially from the dangers of possible combination with foreign interests, and at the same time permit very profitable mining.

Far the larger withdrawals of public lands are not in aid of future legislation, but in connection with the administration of an existing statute, the coal land law which fortunately provides for disposition at prices expressive of value. Known coal lands are therefore withdrawn from entry only long enough for the Geological Survey to make the necessary field examination, and since 1907 coal lands have been sold at prices fixed by the Geological Survey primarily on the basis of the determined quantity and quality of the coal available for mining. The extent to which this business policy is being applied to this one branch of Uncle Sam's

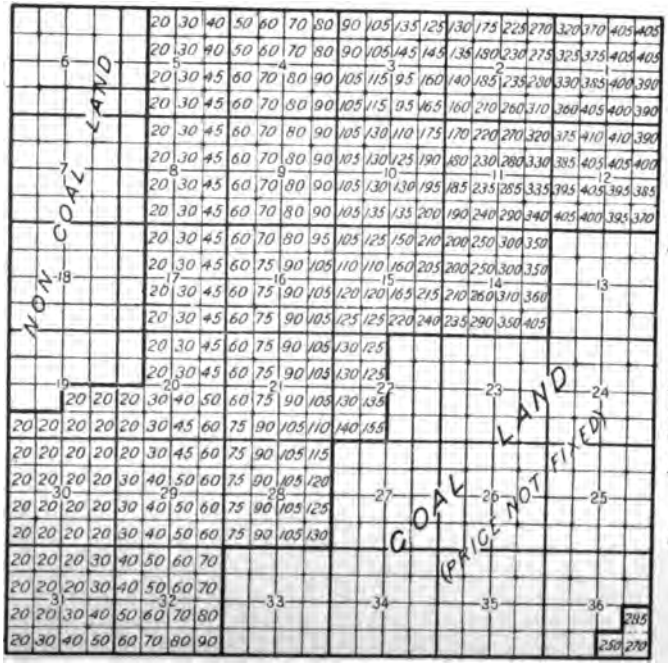
Resurvey T. 19 N., R. 105 W. of the Sixth P.M., Wyoming

Coal land price not fixed because General Land Office records show it to be in private ownership

Replacing plat transmitted by Geological Survey September 8, 1909

Large figures give price in dollars per acre

Coal land within 15-mile limit



	Acres
Coal, priced	13,819
Coal, not priced	6,634
Non coal	2,775
Total	23,208

As given	$1,773,289
Minimum	276,381

I classify and price the land in this township as shown hereon

Geo. Otis Smith
DIRECTOR

U.S. Geological Survey
May 28, 1910

real estate business may be judged from the record of coal land valuation. Up to date, a total of nearly 17½ million acres have been appraised with a avlue of nearly $750,000,000. Yet, the outstanding withdrawals of unclassified coal lands, not including Alaska, comprise 66 million acres, of which approximately 75 per cnet., or 50 million acres, are believed to remain in public ownder-ship.

The railroad engineer in acquiring his right of way across the public lands must now coöperate with the federal officers, in all cases where his located line may cross withdrawn power-sites or other reserve land. The determination of what constitutes the higher use of a river bottom or canyon floor usually necessitates the consideration of all the physical data available and the question is often a nice one whether or not to sacrifice future power development to present railroad construction. To a large extent, no one can be more vitally interested in that power development than the railroad itself, both as a future user of electric motive power and as the common carrier dependent in part upon freight of local origin. Thus, the up-to-date engineer is often ready and willing to submit to such changes in grade as will protect the power possibilities and yet not involve prohibitive increases in construction or operation coats.

The irrigation engineer is today face to face with the necessity of working out his water supply problem with both State and Federal officials. Securing water rights from the one he needs grants of rights of way from the other; and in the case of Carey Act projects the irrigable land itself is secured from the nation through the agency of the State. Some Carey Act reclamation projects in the past have proved so unsuccessful as to seriously discredit irrigation investments generally. To prevent the large economic waste involved in failures of this type, a loss in which usually promoters, investors, and settlers all share, the national government has now established a procedure of painstaking investigation of the physical facts. Thus only can we hope to assure development that is safe, because based upon sufficiency of water supply, adaptability of lands to the plan of reclamation, adequacy of engineering, and financial responsibility of the promoters. With these data at his command, the approval of a segregation list by the Secretary of the Interior possesses more than perfunctory value, and the welfare of all interested citizens, whether investors or settlers can be considered as in a measure safe-guarded.

Naturally, the fields of the irrigation and power engineers overlap, especially in view of the fact that the 1891 irrigation law conveys a grant to the public lands needed for an irrigation right-of-way, while under the 1901 power act only a revocable permit for power development can be secured. The natural tendency, therefore, has been to call practically every proposed development an irrigation project, even where the "irrigation" company is discovered to have offered to contract for the sale of all the hydro-electric power developed for long distance transmission, but to have perfected no plans for contractual relations with owners of irrigable land in the vicinity.

The withdrawal of power-sites by the Federal Government to the extent of nearly two million acres has not been actuated by any desire to arrest the industrial development of the West, but these executive acts have the constructive purpose of insuring the highest use of these most valuable portions of the public domain. The conflict in the use of our public land streams for municipal, irrigation, and power purposes is fully recognized, and one of the Survey engineers has recently published a discussion of these relative values. Not only the dominant temporary use of a particular stream, but its highest ultimate utilization must be considered. By this procedure the irrigation use will be given the preference in one case, the power development in another, while in a third the stream may be harnessed so as to serve effectively both uses. It is readily appreciated by an engineer that the complexity of the problem only stimulates the desire to attain the proper solution and make the administrative action on a pending application such as to aid highest utilization.

Here again, unfortunately, the executive officer at Washington often finds his hand tied, though his eyes are open to the needs of the situation. The statutes that control give too little discretionary power and demand revision to meet the business requirements of today. Thus another large opportunity presents itself to the engineers for coöperation in the securing of legislation that will afford capital the desired measure of safety in its investments and at the same time safeguard the public against both wasteful competition and unregulated monopoly. No one can bring to this difficult task a better equipment of training and experience than the engineers of the country, and a lobby at Washington of engineers with high ideals of profession and citizenship would be a power for good.

Finally, all engineers are interested in the faithful performance of all the functions of government by which basic engineering data are collected. You are vitally interested in the public land and the topographic surveys, and in the geologic investigations and the collection of water supply data. These surveys and examinations are proper functions of the federal landlord and the results secured are properly placed at the disposal of all who seek to develop the nation's resources. Today, as never before, the effort is both to make public all these data and to use them effectively in the solution of public land problems.

DISCUSSION

DR. SMITH.—Mr. Chairman and Members of The Engineers' Club: Although I have committed some of my thoughts to paper, I do not wish my talk to be considered as formal. There may be subjects simply touched upon by me that you would prefer to have more generally discussed, and it will not inconvenience me in the least if at any point in the address—if that is agreeable to your officers and to the traditions of your Society—you wish to interject any question or raise an objection to any statement which I may make. I wish simply to present the subject as it looks to me, and I would like to invite the freest kind of discussion, either after my paper or at any point in the course of its delivery.

The work of the Survey is, as you know, three-fold. The first is this field investigative work, or carrying on of the topographic surveys of the whole country, the making of geologic investigations which will result in the mapping of the whole country, and the determination of the water resources and the determination of what will constitute their highest utilization. These three fields are occupied by three field branches of the Geological Survey, and we now have a fourth, which is the Land Classification Board, which takes from the other three branches the data relating to the public lands, and on the basis of these data makes reports to the Secretary of the Interior and the other bureaus, the Land Office, and the Indian Office, reports that will guide those officers in the administration of the public domain. We act as the technical engineering advisors of the Secretary of the Interior, and of the President.

MR. BALLINGER.—Did I understand you to say that the legislation you are acting under is somewhat antiquated?

DR. SMITH.—Archaic, I think I said.

MR. BALLINGER.—Is that the result of neglect on the part of the Courts, or are those who know most about it interested in leaving the laws as they are?

DR. SMITH.—Of course, it is a delicate thing for a member of the executive branch of our Government to criticize the legislative branch; but I think I am violating no confidence when I say that many members of that branch realize that the land laws are hopelessly out of date, and this is due to many causes, The largest part of the membership of the Lower House, of course, comes from the more populous States of the East where there is very little appreciation of

the needs of the West. In the case of the representatives of the West, too often there is lack of agreement as to what requirements of the East should be met. I think there is some agreement at the present time along the line of revision of our mineral laws; I think the consensus of opinion is that there should be some such revision of our land laws, and I think what is needed more than anything else is, what I have already indicated, concerted action on the part of the various engineering bodies of the country looking to a movement whereby not only will the courts be stimulated to make the needed requirements, but, in making those amendments, will be guided by your knowledge of what is needed. Congress in quite a few cases has acted quite promptly. The withdrawal of 1910 provides for the control of these tracts of land very plainly, with the purpose of withholding land from proper entry pending the enactment of a law which will provide for their proper entry and their alienation, or, in many cases, their leases under proper terms and conditions. I think progress is being made, but it is rather slow.

MR. BALLINGER.—Has there been any objection on the part of the Government to preparing a bill which would amend those conditions?

DR. SMITH.—In that connection I may say that within the past five years we have drafted bills almost without end, and such bills have been introduced, but no action has been taken on them, largely, I think, because of considerable objection to the leasing principle; but that objection is fast passing away in the West. In the case of oil lands, some of the men on the ground see no disadvantage in leasing from Uncle Sam, as contrasted with leasing from the man who got it from Uncle Sam for nothing.

There is one matter that is pending even now, a draft of a leasing law for potash deposits. It is now before the Secretary of the Interior for his consideration. There are certain interests that are very much interested in getting some method of working the deposits of Searles Lake for instance, in Southern California, and it looks to some of us as if the different interests might get together, and if they do, and all push together, the probable result would be that Congress would pass the law. In other words such a thing as that can be done very speedily if everybody is pushing on the same end of the proposition; it is when they are divided and pushing on opposite ends that nothing is done.

MR. E. M. NICHOLS.—Can you state relatively the value of the potash deposits of Searles Lake in comparison with the German deposits of phosphates and potash?

DR. SMITH.—I think I would be going pretty far if I made such a comparison, but I believe there is a large quantity of potash that is available, and some engineers who have investigated, believe that it can be extracted at a cost that will enable the product to reach the Mississippi Valley, for instance, and compete with the German product, not at the present prices of the German product, but at the price to which the German producers, it is believed, can lower their product. Of course, cheaper potash ought to reduce the high cost of living.

MR. NICHOLS.—What are the transportation difficulties in getting to the Mississippi Valley?

DR. SMITH.—As I remember, it is a matter of some twenty miles from the end of the Southern Pacific line extending from Mohave up into Owen River country, and I presume they might have water shipments through the Panama Canal.

MR. NICHOLS.—How far is it, then, from tidewater on the Pacific Coast?

DR. SMITH.—I have forgotten the distance; it is not far from either Daggett or Mohave. I do not understand there are any difficulties in constructing that connecting link of railroad; but what gives me the greatest confidence in the Searles Lake proposition is, that there are at least three or four interests that are trying to get control. I believe there is something in it. They are English interests, and may be connected with German interests.

DR. CHANCE.—Have these lands been withdrawn from entry?

DR. SMITH.—There is a withdrawal pending. (Made Feb. 21, 1913.)

DR. CHANCE.—I would like to ask whether the difficulties in legislation do not arise very largely from the fact that those most interested have failed to agree. We have had the mineral law, under which all gold and placer mines come; they have been discussed by miner organizations, and we know that the law is a bad law; mining men have been dissatisfied with it, and the Supreme Court in decisions covering a number of cases of litigation which were carried on to a final conclusion, practically made the mining law that we have today. Now, whenever a proposition has been suggested that a bill be introduced in Congress, to make any modification of that law, or substitute another law for it, the mining men have been content to let it stay as it is, being afraid that Congress will give us something worse than we already have, and so they decline to support any legislation.

It seems to me that this whole land question is involved in very much the same difficulty. The East is not satisfied to have the disposition of the lands that the West would like to have, and the West is not satisfied with the land laws that the East would like to prescribe. We send to Congress bodies of gentlemen who know nothing about the problems of the Geological Survey or the problems with which they have to deal in these land matters. Our Government is an Experimental Government, and we have to learn about these things.

This question of a placer location has been a vexed question for over forty years, and Congress and the Departments at Washington have seen fit to interpret that law to extend it to oil lands and stone quarries, and other things that are not placers; but, at the same time, the title to tens of thousands of acres of lands are based on that theory.

DR. CHANCE.—Is there any movement on foot now to replace these antiquated laws by some that will cover all these difficulties, both as to mineral locations, locations of different classes of mineral deposits, a great many of which are not lodes, and deposits of such things as potash, borax and oil; cannot one law be made to cover the whole number of cases?

DR. SMITH.—In the first place, I suppose Dr. Chance and others are familiar with the fact that there is a Committee of which Mr. Horace V. Winchell is Chairman, which has been taking up this matter of the Apex Law. They sent

out a circular letter in order to get the ideas of representative people on this matter and I understood from Mr. Winchell that the replies were practically unanimous to the effect that the Apex Law should be done away with. There seems to be a consensus of opinion, but an absence of action.

In regard to the other laws, I do not know that there is any similar concerted movement. I think we would make a mistake if we tried to do too much with any one law. We have made the placer law a sort of panacea. When oil was discovered in California, we said we will pass a law to fit the case, and we simply applied the placer law to the case of oil. When placer gold is discovered, it is discovered in many cases on the surface, whereas the discovery of oil necessitates the work of months and the expenditure of tens of thousands of dollars, and during that period in which money was being expended freely, there exists not only the possibility of jumping the claim by putting up other paper locations, but there was also the possibility of a man with more capital and a better rig coming in and drilling at a faster rate, and striking oil first; he might pump it all away from the first man, and what would be considered the original man on the ground was absolutely without recourse. I think that is the trouble with trying to do too much with one law.

Now there was asked the question, why could we not apply the law for potash to phosphate as well? Well, phosphate could better be compared to coal in its occurrence. The amount of area that a man should be given for potash is quite different to the area a man should be given for phosphate. The trouble with such an occurrence is, for instance at Searles Lake it is only 20 feet below the surface, and you get the brines all ready to pump it out.

MR. NICHOLS.—Isn't it largely a mere shovel proposition?

DR. SMITH.—No, it is a pumping proposition, and if a man wants to get it out, he needs control of a large part of that concentration basin. As a Philadelphia man says, you need to have only one acre, and you can dig a hole and pump the whole thing dry for a mile around. I think it was the same Philadelphian who said you only need one straw to drain a mint-julep.

MR. DUBOIS.—Is there any basis for the remarks as to a change in the Apex law? The fact would seem pertinent that a great majority of the Members of Congress are lawyers, and are therefore interested to see that the right kind of legislation is going on. Is there any real basis for getting away from the Apex law?

DR. SMITH.—I think I can quote one ex-representative from the State of Nevada, who wrote me that he saw I had come out against the Apex law. He said the Apex law has been the salvation of the Western lawyer, and if you do away with it, the miners will get all the money and the lawyers none.

DR. HERING.—When the land grants were made to the Western railroads, did they exclude or include mining rights?

DR. SMITH.—Those grants excluded mining rights, with the exception of coal and iron, which should be considered as not a mineral for the purpose of this act, it being considered that coal and iron were essential to the construction and operation of the railroads, so that the Northern Pacific and the Union Pacific

had coal lands included in their grants, and there was no basis for any contest. The Northern Pacific also got some valuable iron lands, but in the case of the Northern and Union Pacific, their holdings of coal lands are very valuable. At the present time we know they are valuable, because, as they take every other section, their lands are necessarily closely associated with the public lands. And in our land valuation scheme it is not worth while for us to make a distinction between railroad lands and Government lands, because the grading of the prices varies with depths, and also with the thickening or thinning of the coal vein itself. It is easier for us to go right across a township.

I told Vice-president Cooper, of the Northern Pacific, that I thought he owed something to the Geological Survey because we were putting what we thought was a very careful valuation upon the coal lands belonging to the Northern Pacific. He says, "Yes, you are, and the Tax Assessors are taking your valuation."

MR. NICHOLS.—Well, are those coal lands very valuable?

DR. SMITH.—Very valuable, indeed.

MR. NICHOLS.—Are they largely lignites?

DR. SMITH.—No, it is only in the Dakotas that the lignites of low grade occur. Farther west in Wyoming and Montana the coal is a good steaming coal. Our land prices vary from $20 to $450 per acre.

MR. W. C. FURBER.—Is it the policy of the Government to give away, absolutely, coal and oil lands?

DR. SMITH.—No, much of that land has already been withdrawn. There are several suits in California which involve many millions of dollars worth of oil. The Southern Pacific are taking up large acreages of oil land under the non-mineral grant. In defense of their suit they have two defenses; one is, that oil was not a mineral at the time they took this land up, and the other one was, that they did not know there was any oil under the land. But they were very successful in picking out the best oil lands. The Department of Justice is waging a very good fight, and one which I believe will be successful in bringing back to the Government some of that oil land. The other suits are in regard to the withdrawals, and the question has been raised whether the earlier withdrawals, which were made on the recommendation of Secretary Ballinger, n 1910, before the passage of the Withdrawal Act, whether those withdrawals can stand in law. There are a good many locators that went in and began drilling, or in some cases continued their drilling to the point of discovering oil. Between the time of the earlier withdrawals and the later withdrawals, the later withdrawals being under the specific law of 1910, which authorized the Executive to make such withdrawals, the Government's position, I believe, will have to rest partly upon supervisory power of the Executive to handle the public lands, but more especially on the fact that those withdrawals were made in terms of the Federal purpose of supplying the Navy. I happen to know that the Geological Survey made the first recommendation for the withdrawal and the principal reason was the need of the Navy keeping a supply of oil for its own use, and I think this alone would justify the withdrawal, even without the statute. For

the purposes of the Navy there has been a permanent reserve created, including some of the land that is contested in the courts between the Government and the Southern Pacific Railroad.

DR. HERING.—Is it known what the value of these coal lands are in Alaska, about which there has been great dispute in the last two years?

DR. SMITH.—That question is yet in dispute. Take the lands in the Bering River field, the lands that were claimed by the Cunningham group of claimants; there is coal in large quantity there, but the ground is badly faulted and disturbed, and it is a matter that needs very careful engineering and exploration to determine just how valuable those coals are. The quantity is there and the coals must be good, but the costs, I believe, are going to be greater than some of the magazine articles indicate.

While we have been discussing coal, the California oil has taken the full market for the Pacific Coast, and I believe the California oil will dominate the Pacific Coast market.

DR. HERING.—Have the people any rights to the oil lands in California?

DR. SMITH.—There are large areas that have not been touched. No one has been able to enter that land, at any rate since the withdrawals of July, 1910. All over the fields there are unpatented lands, but even there it is a question of what is the range of pumping. I thought that the oil under those lands was a very mobile affair and it could be compared to that mint-julep proposition. But after being on the ground and hearing the testimony of the most experienced drillers, it looks as if it was difficult to pump your neighbor's land. You can take the gas pressure away from him, but as to pumping dry his land at some distance from your wells, it would take some time to do that. Take Derrick Avenue at Coalinga, it was found that some of the wells on that Avenue at no great distance from where wells had been pumping for many months, the later wells had almost as good a flow, but they were pumping wells from the start. There was no gas pressure there; the gas pressure had been taken by the earlier well, but they were good pumping wells and they kept up, and apparently the land on one side was holding as well as on the other.

MR. LEHMAN.—How does that coal in Alaska compare with our coal here?

DR. SMITH.—You could compare it with the Pittsburgh or Pocohontas coal. When we were being investigated I could have given you the B. T. U.'s of these coals, but we have forgotten some things that we were primed with. I am speaking of the Bering River and the Mantanuska coals; those are the two most promising. The fields are not so large as some of the fields in the States. Whether it is a marketable fuel at this time I do not know, it is a question of depth. The demand for coal on the Pacific Coast is not very great. It would take only a few of your good sized Pennsylvania mines to meet the whole demand of the Pacific Coast. You see we have coal from Australia coming in there, and those coals come in under conditions that are not dependent upon the local coal market. Ships come in there with coal for ballast. At the time the Survey made a review of the coal resources o the United States, some ten years ago, I summarized the conditions on the Pacific Coast, as I was working then in the State of Wash-

ington, and I noticed that the imports of coal into San Francisco depended not so much on the demand for coal, as it did on the size of the wheat crop. A large wheat crop would call in all the tramp steamers from the Pacific ocean and they would come in in ballast, and you could see a very definite relation between the coal imports and wheat exports, and that would regulate the freight rates between San Francisco and Australia.

MR. NICHOLS.—Do you recall what the freight rates were between San Francisco and Australia?

DR. SMITH.—In that case I question whether the freight rates would be anything. You see conditions like that are abnormal factors in the competitive market.

DR. HERING.—Do I understand that the coal lands now belong to the people again?

DR. SMITH.—Yes, the Cunningham claims were thrown out of court. One interesting feature is, that the Government went in and mined some coal on the Cunningham claims; this was for the purpose of making some experimental tests by the Navy. I heard from Alaska that those in charge of the Cunningham properties did not make any protest, inasmuch as all of their people on the ground were employed by the Government, and they did not want to take a good job away from their own people.

MR. BALLINGER.—I remember reading something over a year ago that the construction tracks and rolling stock of the Panama canal would soon be out of use and they were to be loaded on vessels and taken up to Alaska and used for the purpose of building a railroad, so that the Government could mine its own coal and ship it to its own vessels. I understood that some time ago Secretary Fisher was thinking favorably of that matter.

DR. SMITH.—Of course, we all know that what Alaska needs more than anything else is transportation, to develop its mineral and agricultural resources. Now, in the light of the authorization by the last Congress of a Railroad Commission which is now in session, something is likely to be done along that line. Its Chairman is Major Morrow of the Army, and its Vice-Chairman is Mr. Brooks, of our Survey, and there is a Naval Constructor, Mr. Cox, on the Commission, and a Railroad Engineer, Mr. Ingersoll. They visited Alaska and made a careful investigation, and are now preparing their report. I suppose that the President will receive that report and will transmit it to Congress, and I expect you will have a fair-minded and authoritative report on the needs of Alaska in the matter of railroads, and probably suggestions as to the best way of meeting those needs. I think that is a case where Congress acted wisely in getting someone else to collect that information, and I hope something may be done to remedy the railroad conditions. I think possibly the Guggenheim Road may be glad to sell out. In their case the railroad was needed to reach the copper properties, otherwise that property would remain undeveloped.

MR. NICHOLS.—How long has this Commission been in existence?

DR. SMITH.—They were appointed during the last session of Congress; they

are not six months old yet. It is all too short a time in which to take up a proposition of that sort.

MR. NICHOLS.—Are you doing any photographic survey work in the United States?

DR. SMITH.—No, not in the United States proper, only in Alaska.

. . . . . .

DR. HERING.—Is the boundary line located now all the way to the Arctic Ocean?

DR. SMITH.—Yes, I believe it is.

DR. HERING.—Is the Alaska steaming coal as good as the Pennsylvania coal?

DR. SMITH.—I think it is.

DR. HERING.—How would the coal fields of Australia and China compare with the coal fields of the other countries of the world?

DR. SMITH.—I do not think we know enough about China to make any comparison.

MR. NICHOLS.—Is there any restriction on the exportation of coal from Great Britain?

DR. SMITH.—I think there has been recently. I was talking with the Director of the British Survey some years ago—I knew that he had been a member of the Royal Commission to take up the question of coal supply, and I asked him if his Commission made any recommendation that the export of coal be prohibited. He said the Commission did consider it, but they did not want to make any recommendation that might be laughed at by future generations. He said that when the English army depended upon bows and arrows for its fighting material, the cry went up that yew wood was giving out and there would soon be insufficient yew to make the bows out of in England, while Germany had immense forests of yew, and it was predicted that when the supply in England was exhausted, the Germans might come over and take possession of the island. Likewise, the Admiral who succeeded Nelson decided that the supply of oak timber would soon be expended and there would not be enough to build any more ships of war, and when he was an old man he would go about with a pocket full of acorns and a long walking stick. He would make a hole in the ground with the end of his stick and plant an acorn wherever he could. Some of those oak trees are now ready to furnish timber for the battleships! Therefore, bearing in mind, I suppose, some of these predictions of history, the Commission did not make any recommendation regarding coal exports. They realized, moreover, that it might interfere in a serious way with the whole complex arrangement of manufactures and commerce.

Q. (Mr. ?).—Would you discuss briefly the prospects of the use of the oil shales in the middle West?

DR. SMITH.—Similar oil shales are and have been used for a long time in Scotland for making a kind of mineral oil, but I do not think the time has come for their profitable use, when we have crude oil selling as low as it is in some parts of the country.

MR. WALTER LORING WEBB.—What is the average price for that coal land?

DR. SMITH.—It would be about $41. Land sold in the past five years has averaged only about $18. The law provides a minimum price of $10 further than 15 miles from a railroad, or $20 within 15 miles of a railroad.

Q. Is that fee simple?

A. Yes, fee simple. We try to figure out what would be the present value of a leasehold for so much coal land, and at that rate it means that it would be a price at which you cannot afford to pay to hold the land without operation, but we believe it is a price you could afford to pay in order to develop. We have a separation law by which you can go on even our withdrawn land and cultivate the surface, in which case you receive a limited patent. The Government reserves the coal underneath, and in that case you are protected against damages. In the Western country the law provides that if there are other minerals, the possession of the upper estate implies the right to the lower also. For instance, if you were to find placer gold with a gravel overlaying the coal, you would be entitled to the coal too.

Q. How about it in the case of the coal being sold?

A. Under the present coal land law we just give away the land in every respect.

MR. S. M. SWAAB.—How thick does the coal have to be before it is commerciably valuable?

DR. SMITH.—We have a sliding scale, but we call coal valuable at anything within 3,000 feet of the surface.

MR. S. M. SWAAB.—Doesn't the proximity of the railroad become a factor?

DR. SMITH (Referring to Lantern Slide), indicated.—If this happened to be just outside of the 15 mile limit, the price might be $270 for that forty, and this forty would be $135; if a railroad should go in there, the value of that land outside of the 15 mile zone would be doubled.

PAPER NO. 1125

THE UNWRITTEN LAW

BY MANTON E. HIBBS.

Read Feb. 15, 1913

INTRODUCTION

Travelers tell us that at Moscow there is preserved a double seated throne. In the front are two seats; seats for two brothers, Ivan and Peter, while in the back was an opening hidden by a veil of silk, and behind this sat Sophia, their sister. This piece of furniture was a symbol of the government of Russia at the end of the 17th century. It was composed of two visible czars and one invisible sovereign. The building laws of a city or state is a visible symbol of municipal authority, but what of the invisible sovereign that so often defies its authority and sometimes defeats its ideals? This invisible sovereign, for our purpose this evening, we have called the "unwritten law," and with your kind indulgence we will attempt to throw some light upon this invisible king and suggest some means at least to curb his power.

Upon looking over a number of building codes of our great cities, the first thing that usually attracts your attention is the large number of pages and its specific details of items that are really unessential for "Public Safety." When a building is erected without the pale of a building law, the specification of the engineer or a chitect takes its place, but in large cities or growing commun[r]ties, owing to the fact that buildings are upon public streets and imust be of necessity owing to the want of available space adjacent to each other, it is absolutely essential to have a building code for mutual protection. This is the genesis of a building law of a city.

Some of our building codes have placed a standard specification of steel or concrete of good reputable authority on their pages and there it remains year in and year out, although its original source has been modified to suit the advancement of the science that it

particularly covers. A distinction, therefore, should be made in the make-up of a code as to what is really essential to public safety as a whole and the remainder of the problem should be left to individual department or bureau to work out. For instance, it is absolutely essential that stringent laws should be enacted covering walls, character of soil on which all buildings must rest, exits, stairways, because these are essential to the main body of the city, but to fix permanently the bearing value of rivets and similar details is not only a waste of strength, but it defeats its very ideal in the end.

In other words enact in your own law all that matter that can be applied to the city as a whole and whose conditions will be probably fixed for years and give the office that applies the authority the right to make regulations for structural conditions. For example, why should a wooden or steel column formula with a fixed factor of safety be incorporated in a building law to remain for ten years or more, while the art of structural advancement in those ten years may show such a formula absurd? Let me make myself clear on this point by taking an example from the records of the Philadelphia Bureau of Building Inspection.

On the 25th of April, 1903, Governor Pennypacker approved a building act known as No. 236 for the erection of buildings in the City of Philadelphia. At that time reinforced concrete was in its infancy and taking the authority of concrete designers at that time a safe unit stress on the bending of slab griders, etc., would be 500 lbs. per sq. in. for concrete. In the year 1907, a committee was formed of interest in building line of which this club sent its representatives (Engineers' Club) and together with the Chief of the Bureau of Building Inspection, Edwin Clark, to formu ate regulations governing the erections structurally of concrete buildings. Henry Clay, Director of Public Safety, approved these regulations on the 10th of October, 1907. Later on, in a few months, an engineer on concrete was appointed to carry out in the field these regulations. Those regulations in place of 500 lbs. per sq. in. substituted 600 lbs. Since 1903, Act No. 236 has not been changed. Suppose in place of the year 1907 that committee had formulated your regulations in 1903 and had placed 500 lbs. per sq. in. in it and these regulations had become a law in 1903. What would have been the result?

Again taking the records of the Philadelphia Bureau of Building

Inspection the cost of concrete buildings from January, 1908, to December, 1912, amounted to $10,000,000 (126 buildings). Taking a slab construction alone of 3½ in. and basing it on a span 4 ft., 10 in., and making a calculation based on 500 and 600 lbs. per sq. in. of concrete and also taking into consideration the areas of all floors except the first the owners of those buildings would have been saddled with an additional cost of $8,000 on slabs alone since 1908 with practically no additional safety. If the Philadelphia Bureau of Building Inspection can certify to and inspect with competent men under regulations, concrete buildings structurally, why cannot it be done with a steel building or any other building structurally.

In other words, take your structural details out of the law; incorporate them in regulations subject to change with the advancement in the art of building, and your unwritten law will never lay an unjust tax upon you.

Having placed your structural portion in regulations more attention should be given to the development of law affecting a city as a whole. In the year 1900, under orders of Director A. L. English, Chief Hill of the Philadelphia Bureau of Building Inspection made an inspection of the fire-belt bounded by Vine, South, Broad and the Delaware. When that inspection was completed, numbering 3,620 buildings, about 8% were ordered to have outside metal fire-escapes. Again in 1903, a portion of the same area, Vine to Walnut, Broad and Delaware Avenue, was inspected —4,992 buildings—10% of which were ordered to have outside fire-escapes.

These two special inspections show a tendency as to how a city develops. Under the "Philadelphia Law" for old buildings the outside metal escape is ordered on buildings when the third or above floors are occupied by persons not using the building as a dwelling. An inspector enters a building and finds the upper floors vacant. He leaves and may never see the building again until months afterward because of his general work, and then he finds the upper floors tenanted. A family moves out and our Russian friends with their numerous offspring and cousins move in and the dwelling becomes a tenement. In other words, the floating population of a great city can never be taken care of properly unless you have a large number of inspectors—a tax which our cities are not willing to pay.

Take another instance of growth. In New York City about fifteen years ago the "Garment Makers," afraid of the tenement label and having no regular factories began to rent "loft" buildings. With this change, light motors run by electricity came into play. The cloak makers, suit makers, white wear makers and furriers followed and soon all the available loft buildings were filled. The speculative builder, seeing the trend, began to erect more. This is how the factory district of New York in the neighborhood of 14th Street grew. As there were restrictions above 12 stories this became the prevailing height for the loft factories. 1901 to 1910—790 of these buildings were erected at a cost of $138,000,000. No inspection could be made of these buildings after they were occupied because the New York Building Inspectors had their hands full in the inspection of all new work and their other customary duties.

PHILADELPHIA BUREAU OF BUILDING INSPECTION. 1900–1912.

Year.	Operations.	Cost in Millions.	Visits of Inspectors.	Men.	Average Visits, per Day.	Total Condemnations Dangerous and Law Violations.	Dangerous Condemnations.	Percentage of Dangerous Condemnations.	Number of Dwellings Erected.	Cost of Dwellings in Millions.	Fire-Escapes Erected
1900	11506	20.8	47894	12.	18	1044	389	37	3112	7.3	432
1901	12840	29.5	46273	10.7	19	1001	425	42	4582	9.8	175
1902	11359	28.7	43366	11.4	17	961	491	51	4216	9.2	295
1903	12003	32.5	50994	12.	19	1210	566	46	5180	11.2	201
1904	14152	28.9	51280	11.8	19	1649	683	41	6635	15.1	674
1905	16958	34.8	48297	11.2	19	1928	572	30	9420	21.1	440
1906	17872	40.7	54206	11.4	21	2147	714	33	10145	22.8	163
1907	15999	36.6	55960	13.1	19	1525	667	44	8441	18.5	199
1908	13950	28.4	67820	15.7	19	1542	654	42	6275	14.5	314
1909	17294	42.9	67809	15.2	20	1614	666	41	9820	22.1	120
1910	16383	37.8	65470	14.5	20	1900	608	32	9143	21.5	250
1911	16215	40.0	78562	17.8	19	1885	917	49	8629	20.5	196
1912	14707	37.1	104316	21.4	21	2322	1183	51	5174	13.4	387

Population of Philadelphia, 1,549,008.
Area of Philadelphia, 129.6 square miles.
Dwellings in Philadelphia (1910), 295, 220.

MANHATTAN BUREAU OF BUILDING INSPECTION. 1902–1911.

Year.	Operations.	Cost in millions.	Visits of Inspectors.	Men.	Average Visits, per Day.	Condemnations and Dangerous Law Violations.	Dangerous Condemnations.	Percentage of Dangerous Condemnations.	Number of Dwellings Erected.	Cost of Dwellings in millions.	Fire-Escapes; Cases Filed.
1902	2877	89.9	157243	47	14	7076	2917	41	157	7.8	1711
1903	3306	86.5	172585	65	12	6131	2616	42	72	3.2	1025
1904	3816	84.2	139421	63	10	5629	2471	44	84	2.7	532
1905	7041	138.9	132981	60	9½	5919	2610	44	94	4.4	341
1906	5582	126.1	133190	62	9	5583	2181	37	55	2.2	418
1907	4802	91.7	122731	65	8	5984	2149	36	65	2.6	708
1908	3498	95.5	112534	66	7	5473	2026	37	36	1.4	922
1909	4573	144.3	119049	66	8	4225	1864	44	55	3.2	496
1910	4205	108.6	153614	62	11	6835	2341	34	43	1.9	872
1911	4426	111.3	170224	60	12	7350	2914	40	39	2.2	3853

Population of Manhattan, 2,331,542.
Area of Manhattan, 22 square miles.
Dwellings in Manhattan (1910), 75, 410.

BUILDINGS TEN STORIES AND OVER (1912)

Stories.	Buildings.
10	179
11	181
12	191
13	389
14	44
15	27
16	28
17	31
18	13
19	13
20	12
21	15
22	11
23	3
24	4
26	4
27	2
31	1
32	1
33	3
38	1
41	1
45	1
55	1
Total	1156

Upon the analysis of figures taken from the records of the Philadelphia Bureau of Building Inspection and the Manhattan Bureau placed as near as the writer was able to bring the latter in conjunction with the former, you will notice that Philadelphia Bureau men from 1900 to 1912 are making from 17 to 21 visits per working day on new operations work, and the New York men with their high buildings were making from 7 to 14 visits per day—the year being divided into about 230 days available for inspection of new work. Probably the New York figures would run higher if the writer had the actual time of the number of inspectors employed. You will readily perceive from the statements of the two bureaus that there is very little time left to take care of the floating population of any great city.

How many men should a large city have in order to take care of this emergency might be asked. In October, 1911, in order to put into operation the new fire prevention law produced practically by this floating condition, Fire Commissioner Johnson, of New York, was asked how many men he wanted and how much money. He calmly replied, 535 men, and $750,000. He was able to get 125 inspectors. Inspection then is a mere matter of money and men; and our cities with a few available inspectors can only make a cursory of supplemental inspection. This is a financial ill that the unwritten law is inflicting upon us today and there is little prospect for relief.

In cities most of the buildings have not been built, from the modern standpoint, under any law. Our fire-insurance men loudly proclaim from the mountain tops our fire losses and yet our building laws make no inducement to eliminate our wooden floor buildings. Having no inducement our people put up the same kind of buildings that have been destroyed.

In looking over a number of building codes of our great cities, you will find three main classifications of building, fire-proof, mill building, and joist construction. Suppose, for instance, a man wants to put up an apartment house and the law only allows him four stories with mill or joist construction, and if he wants another story he must build fire-proof. He builds four stories and another wooden floor building is added for the conflagration that our insurance men are predicting. Why not say to him, "Build six stories with steel beams and cinder concrete floors, fire proof with 1½ in. of cinder concrete throughout, and we will let you build

60 ft. high. The inducement of such construction might be means of getting rid of a four story wooden floor construction and you would certainly get a better building so far as fire-risk is concerned. To ask that a six story building should be fire-proofed the same way as a 14 story building is to the writer not logical. This classification of joist, mill, and fire-proof construction is a classification of the underwriters and not a classification to meet the need of a great city as a whole.

There are some clauses placed in building laws that are doing an infinite amount of mischief. For illustration look at the Old Academy of Music, Philadelphia, as it stands today after years of faithful service. What holds it there but the clause in the theater act of Philadelphia that reads "all theaters or places of amusement now existing may be altered providing such alteration does not amount to a virtual reconstruction thereof, so as to make it a new building"? Yet the city of Philadelphia forces a competitor on the other side of the street to conform to the same theater act which entails a fire proof construction. Read the history of all theater disasters from the Ring Theater in Vienna, 1881, to Iroquois Theater of Chicago in 1903, and you will find the same tale of disaster. A sudden rapid fire on the stage and death in the gallery. There certainly ought to be qualifying phrases in the codes with enough power to make the stages of our old theaters fire-proof. Take another example from Philadelphia. Let me show a picture of an old fire escape. You will notice the position of the drop ladder. I am not showing you this because of its position, but rather to draw your attention to the ladder. Why does it remain as an old relic of by gone days? Simply because "the clause" provided that nothing in this act shall interfere with fire escapes now in use approved by the proper authorities." Look at the modern one with its well balanced counterweight. The one is ready for action while the other actually menaces life.

Nothing in building laws is so often slighted as in the matter of egress of buildings in case of fire and panic, and nothing is fought so strenuously by owner and others than those paragraphs of our law calling for proper and adequate means of exit. To illustrate this question of exit properly, and to give a few principles that govern it, I am going to draw on your patience to describe very briefly three fires. These fires were selected to illustrate phases of fires rather than comparison. I have selected the Asch Build-

FIG. 1.—Two outside metal escapes, both legal under the same law.

FIG. 2.—Asch Building, New York.

ing of New York, a ten story fire proof structure, the Shrack and Sherwood fire of Philadelphia, a six story mill building, and a Newark factory building, four stories high, of joist construction, an old building, whose antiquity can be judged from the fact that Ericsson designed the Monitor there.

On Saturday, March 25th, 1911, about 4.45 P. M. a fire broke out in a ten story fire-proof loft building at the Northwest corner of Washington Place and Green Street, New York City. All floors with the exception of the 6th, vacant, were used as work-shops. The fire started at the Green Street stairway on the eighth floor and spread rapidly through the floor, reaching the upper floors by means of a pipe shaft and outside windows. These three floors were occupied by the Triangle Shirt Waist Factory.

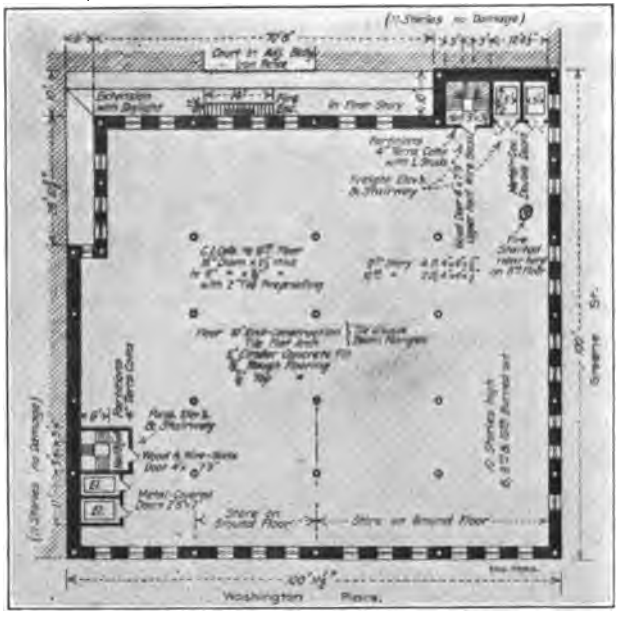


FIG. 3.—Plan of the Eighth Floor of the Asch Building (Courtesy of the "Engineering News").

Out of 500 employees 142 lost their lives. Many unable to reach the exits jumped to the sidewalks. Others tried in vain to reach elevators, fire escapes and stairways. The floor area of each story was about 10,000 sq. ft. The two stairways opening upon the streets had each a clear width of 2 ft., 6 in., with winders. The fire escape, of old pattern, landed on a roof in an area way. Two passenger and two freight elevators, enclosed in terra cotta, were the only remaining means of exit. About 6 o'clock P. M. on December 16th, 1909, fire broke out in a six story mill building situated at 1516–22 Callowhill Street, Philadelphia. It was used as a manufactory for Casket and Undertakers' Supplies, and the stock was highly inflammable. Flames started in the store room of the fourth floor and must have bren burning quite a time before the fire was discovered. A number of girls were working on the fifth floor. Some ran in the direction of the open stairway where the dressing room was located and their bodies were found there the next day. Others with their hair on fire reached

FIG. 4.—Schrack & Sherwood, building, view of the front.

the tower fire escape in the rear, and were saved. The floor area of this building was 3,600 sq. ft. The building had a tower fire escape with stairs four feet wide and an outside platform, an open stairway 4 ft. wide in front (legal under the act of April 25th, 1903) and an elevator shaft of brick.

On Saturday, November 26th, 1910, between nine and ten in the morning, a Newark factory at the corner of Orange and High

FIG. 5.—Shrack & Snerwood Building view of the rear showing the tower.

Streets caught fire. The building was clear on all sides from other buildings. This building was erected in 1855. The lower floor had several exits, but only one stairway enclosed in wood with a 32-in. door, ran from the 4th to the 3d. This door was locked during working hours. The windows were without weights or pulleys, the upper sashes were nailed in place, while the lower sashes had to be held by fastenings placed in position by hand. The window sills were 48 in. above the floor. A fire escape in the

rear extended from the 4th floor to the roof of the boiler house. Over the highway was another fire escape whose descent to the street from the second story was made by a ladder hanging to the third story platform. The fire broke out on the third floor and in seven minutes after the alarm was sounded twenty-five girls were killed out of one hundred and sixteen women on the fourth floor.

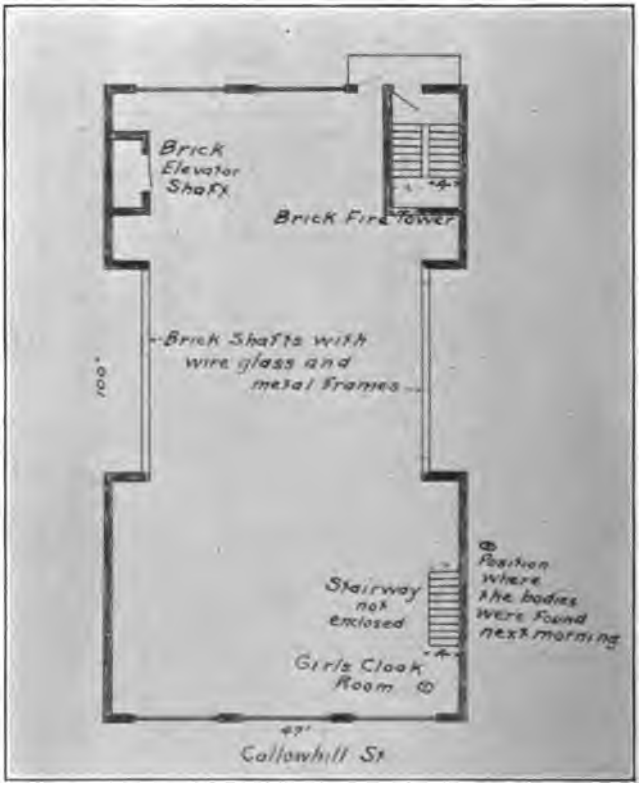


FIG. 6.—Plan of the floors of Shrack & Sherwood Building, Philadelphia

The first point I want to call your attention to from these fires is the question of the lock door problem in the factory. In the New York and Newark fires the lock doors were shown in the cases of court action to be of common occurrence in both of these buildings. In the Asch Building the proprietors, Harris and Blanck, were indicted for manslaughter and were acquitted.

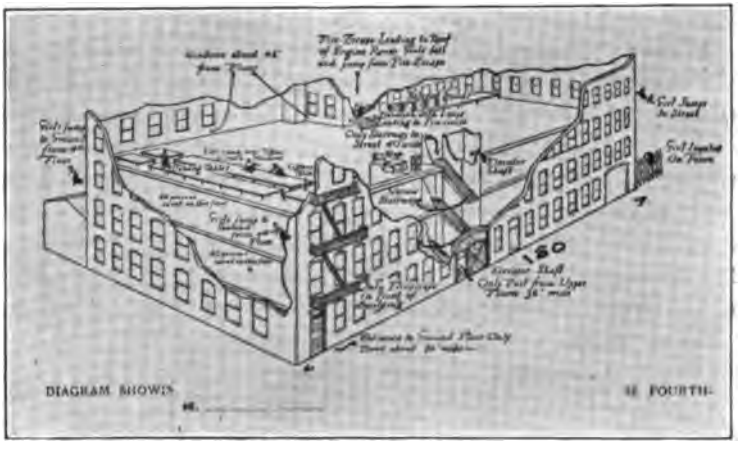


FIG. 7.—Sectional view—Newark Fire.

Now the locked door problem in our factories is a serious one and one hard to solve because the proprietor is often obliged to lock his door to prevent the employees from stealing out of the building during working hours, or else employing additional help to attend the door and watch the employees. But your Grand Jury may indict, your District Attorney may plead, your Judge may charge, but the American Public that sit your jury box can never be con-

FIG. 8.—Ruins of the Newark Fire.

vinced that manslaughter at a lock door point is the same as manslaughter at the pistol point. The solution of the lock door problem is not a $12,000 District Attorney, but a $1.25 axe. An axe should be placed at every exit door for the same reason that one is placed in your wooden passenger coach of your railroads.

In the New York Fire Insurance Exchange the following is a portion of its specification "locate water pails in close proximity to exits such as stairways, elevators, fire escapes." In the cases of the Asch Building and the Newark fire, valuable time was lost in attempting to put out just such fires with pails of water and sand. Such minor appliances should never be put at any exit as it might

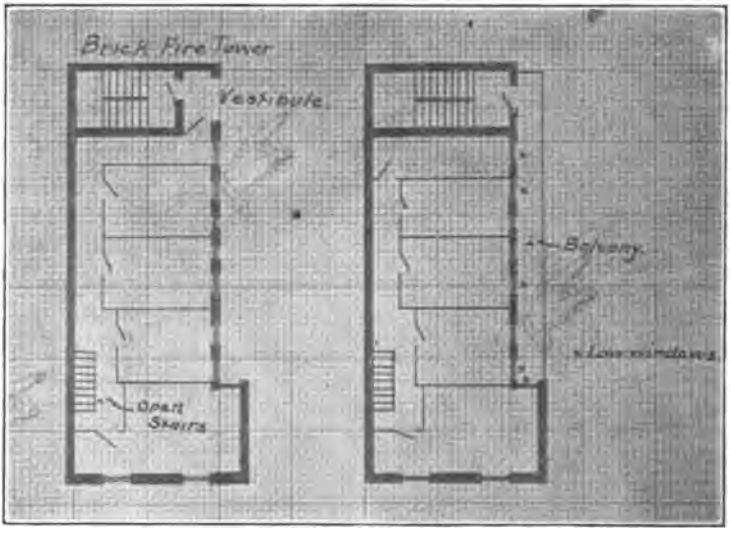


FIG. 9.—Plan showing the location of fire towers, with an inside vestibule or an outside platform

cost a few minutes of valuable time blocking the exits in the attempt to reach the pails and thereby waste life. When the fire breaks out let the building burn and get the people out. Taking a random record of the year 1909, there were in the City of Philadelphia, 3,846 active fires, of which 201 were extinguished by chemical service. If the trained Department, reaching the fires in a few minutes, can only put out 5% of the fires with its minor chemical appliances, what chance has a pail of water to check a fire whose flash is often like a trailn of gu powder? Let the Fire

Department take care of the fire and keep your first few minutes to save life. In talking with your Ex-chief of your Fire Department, Richard Baxter, about this phase of fire, he gave me a homely illustration of a fire in his youthful days, when upon entering a building he found a young girl attempting to put out the fire with a pail of water while her aged grandmother sat in a corner nearly enveloped in flames. Grabbing the bucket from her hands he told her to save the woman's life and soon extinguished the fire, which the girl did not know how to do. The fire departments are organized essentially to protect property and it is about time that our codes were made to protect human life. In the Philadelphia fire, the girls that ran in the direction of the smoke proof tower and the brick enclosed elevator shaft, reached the outside platform of the tower in safety, while some who ran in the direction of the cloak room and open stairway lost their lives. In the case of the Philadelphia and New York fires, the stairway did not have to be enclosed. Is there any reason why any stairway should not be enclosed in some fire-resisting material? Is fire any respecter of floor area? All stairways should be enclosed in some fire-resisting material, not necessarily fire-proof construction, provided with doors of the same quality, that can be easily handled in swinging outwardly. What do you mean by fire-resisting material? Let me give you an example taken from a Philadelphia fire.

On October 28th, 1903, at 3.30 A. M. a fire broke out on the stage of the Girard Avenue Theater, and in a few minutes flames were bursting through the skylights. Upon the arrival of the first fire company, three minutes after the alarm, the firemen finding no fire in the Auditorium owing to the fact that the asbestos curtain was down, devoted their attention to the surrounding property which was threatened by the stage fire. Fifteen minutes later the Auditorium was full of smoke, but no fire beyond the stage. The heat, however, was getting intense and a few minutes later, the entire Auditorium seemed to suddenly ignite and burst into flames. This curtain held the heat and flames back for fifteen minutes. This is what might be termed fire-resisting, and our enclosures could be built safely along these lines. The Fire-Underwriters' door is not only unlovely in appearance, but is absolutely unwieldy in handling and could safely give way to doors that could more readily open or shut without so much effort.

The Underwriters' doors can only be handled quickly by strong men and cannot certainly be opened quickly by a factory girl or boy. I want to remind my hearers as far back as 1899. Under the British Fire Prevention Committee, in fire test on wood lathing, wood studs, and plaster, a partition was able to check fire at 1,600° for 28 minutes. You can readily perceive that a partition could be easily made of some fire-resisting material, and of such a character so as not to conceal fire like a wooden cornice and yet be fully able to protect openings and stairs for a space of time sufficient to get the people safely out of the building.

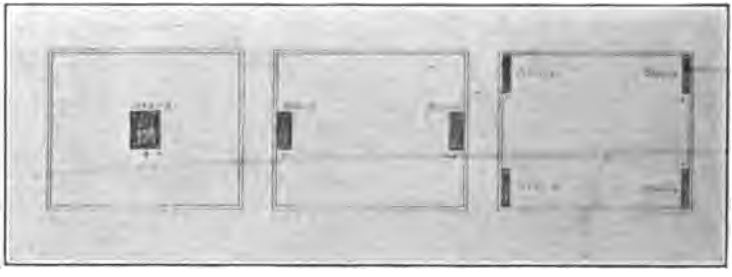


FIG. 10.—Plan showing location of stairways.

Taking up now with the width of stairways, you will notice this man standing in a doorway 32 in. in width, the width of the doorway in the Newark Building, and you can readily see that such a width could only accomodate one person and no more. Taking another picture showing the entrance of the Engineers' Club, which is 56 in. in the clear, and its width is easily filled by two of our members. From carefully measuring existing stairways, aisles, etc. of our theaters, baseball parks, department stores and public buildings, for four years or more, I am convinced that the capacity of stairs is a multiple of 24 in. for each person. In other words, 24 in. for each person determines the capacity of stairs and not mere numerical width. Judging from the Brief submitted by Rudolph P. Miller, Superintendent of Buildings, Borough of Manhattan, to the New York State Factory Investigating Commission, Mr. Miller gives the capacity of stairs as 20 in. per person. But remembering that in a panic, people taking stairs are to be in a safe maximum motion and also are on the incline, it seems more logical to take 24 in. per person.

That this principle of 24 in. per person is not rightly understood

let us glance at an example from a building code and note the result. A portion of the code reads "every slow burning building greater than 12,000 sq. ft. of area shall have at least 3 stairways. The width of stairways shall be at least 80% of the formulæ and no case be less than 12. No stairway shall be less than 3 feet in width."

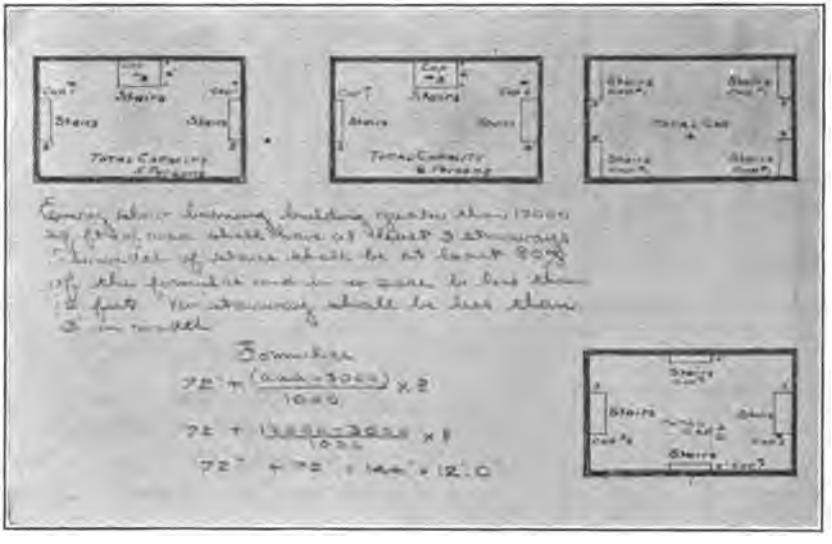


FIG. 11.—Plans showing an example of lawful and unlawful stairs.

FORMULAE

$$\frac{72 \text{ in.} + (\text{area}—3{,}000) \times 8}{1{,}000}$$

Substituting in place of area 125,000 sq. ft. the result would be

$$\frac{72 + 125{,}000—3{,}000 \times 8}{1{,}000}$$

$$72 \text{ in.} + 76 \text{ in.} = 148 \text{ in.}$$

$$= 12 \text{ ft., } 4 \text{ in.}$$

Looking at the plan of building we will divide our 12 feet of width into three stairways of the capacity of 2, whose widths will be 3 feet each and one of six feet in width. The total capacity is five persons. However, if by breaking the law, I now take away one

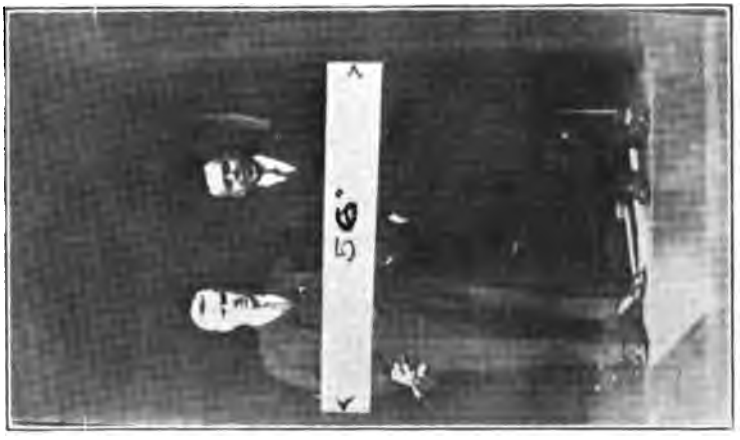
foot from one of the side stairs and give it to the opposite stairs, I have increased the capacity of the stairs to six persons. Again conforming to the law, I place four stairways of 3 feet each in each corner of the building, I have reduced my capacity to four persons, although I have given a greater diversity of exits. Again breaking the law, we divide the width of 12 feet into four exits, two of two each and the remaining two of four each, our total capacity is six persons, and our diversity is increased also. You can readily perceive such formulæ not taking into account width per person is not based on the right principle, for an excess of stairway due to an excess of area will not always bring with it an excess of carrying capacity of the stairs.

Even Mr. Freitag, in his books on "Fire Prevention," makes the rather startling proposition on page 510 of his book when he says —"Assuming that a four foot stairway will accomodate three persons abreast"; further on he speaks of 3 ft. stairs, then 2 ft. stairs in the basement, and 5 ft. stairways specifying kinds of building, rather than the people who use them.

There is more in the problem of exits than the average mind imagines. For example, take the plan of a small apartment house, with a fire-tower in the rear, with an entry leading to its vestibule and an open stairway in the front. Apparently this building has two means of escape, but really has but one because should a fire break out below at the foot of the open stairs, the smoke or fire ascending would block off not only the stairway, but likewise the approach to the vestibule, as the smoke will fill the entry leading to the tower. Plan No. 2 shows a better arrangement if architectural conditions could be modified for every room has two means of exit through the outside balcony.

Another or final word of caution about the location of exits—a glaring error that ought to be avoided, is location of fire escapes in area ways with a proviso of landing people on the roof, which sometimes results in an escape from fire to meet injury or death on the pavement below.

In these three fires very little time was available for persons to reach the exits. Although five minutes is but a short period to struggle for life—and it would seem that this is about the limit now-a-days that the modern fire will give human life for an escape, yet it might be well to look into our buildings to see what can be done in a few minutes. In order to get a personal line on this



Doorway 56'

Doorway 32"

Fig. 12.

matter of exits, I kept a note-book extending over a period of four years jotting down by chance wherever a crowd was present, and afterwards making my measurements of the surroundings. On a stairway 6 feet wide, at the Philadelphia Ball Park, with a crowd very much congested, fourteen files of three each, passed a corner in five minutes, and on another day at the same Park, on a 10 foot stairway, with a crowd not congested, twenty files of five abreast, passed a point in two minutes. Going to a number of buildings—the limit was ten stories—I would place myself at a remote point in the story away from the exit, then walk to it at a moderate pace, and take the time to reach the street by the stairs or tower. My note-book shows the following results:

Two ten-story office buildings, three and one-half minutes.

One ten-story department store, six minutes.

Two five-story department stores, three minutes.

Nine-story department store, five minutes.

Two five-story department stores, three and one-half minutes.

Two ten-story office buildings, three minutes.

Looking at some of our public buildings, the Garrick Theater, whose capacity is rated as 1,800 seats, showed this result when the house was full and taking the descent of the curtain as the time of the beginning of the exit, the lower floor was emptied in four minutes, the balcony in six minutes, and the lights were put out at the end of eight minutes. This represents the average time of the modern theater of Philadelphia in the matter of timing the capacity of the exits. At the Metropolitan Opera House, the balcony on the right side containing about four hundred persons, one-third of which went to two 5 feet exits while the remainder went to one 8 feet exit, was emptied in five and one-half minutes. On the left hand side with four hundred and fifty-seven persons and no emergency exits, but using one 8 foot exit, that portion was emptied in eight and one-half minutes.

At the A. D. Bache Public School—a modern three-story building—four hundred pupils on the third floor and five hundred on the second floor, whose ages ranged from eight to sixteen years, were able to leave the building in three minutes. You can get an idea of the possibility of time from these examples as they are all modern examples, and cover phases of building.

Taking up another point common to these three fires, no one lost their lives by a fallen wall, a broken beam, or any structural

defects. Yet after all fires it seems to be more fire-proofing, less wood, and other things which do not play as much in the saving of human life as our insurance papers would lead us to believe. In looking over the records of the Philadelphia Fire Department from 1901–1910, the loss of the buildings amounted to $6,409,783, while their contents $15,610,220. You will readily perceive for a moment what enormous amount of material goes up in smoke to help to keep the fires going. In a shirt waist or kindred manufacturing line, the vegetable fiber of cotton, linen, etc. is made up largely of cellulose, which is the identical constituent of wood. In other words, such material is nothing more or less than wood in thin sheets ready to burst into flames at a moment's notice. Today the real menace in a factory building are the contents and the people themselves. Upon a moment's reflection, you would readily see how difficult it would be to regulate the merchandise of any factory or department store because in many cases the problem as a whole is unsolvable. However, the people or the human element in a factory is a case where laws can be readily passed for the saving and conserving of human life. Some laws take no account of the human element, but look upon a number of people taking an exit like a mass of water is poured into a pipe. But the human element faints, wears skirts, jams passage ways, fights, and like an instance in the Washington Street fire, fought for places with tobacco knives, even when the real cause was only a panic. How people really act seems so very far away from our laws. Will you pardon me if I give you an illustration from my own experiences? Years ago the writer was a small school boy in one of your public schools and he remembers being on the top floor of the school and hearing the sound of hissing steam from the radiator. Suddenly a cry of fire rang out and the classes rushed to the doors, thrust the teachers aside and made a wild scramble to the stairway, which was an ample one. When I reached it I was the middle boy, and I guessed that I could never get to the ground alive among such a mad crowd, so I made a flying leap ahead to sideways grab the railing and rushed pell mell down the stairs into the street. Was it fire? No, it was the fear of fire, and the fear of fire is worse than the fire itself. Two years ago I interviewed another school boy saying to him "do you have a fire drill in your school?" He not only replied yes, but eagerly told me how the signal for action is given, the arrangement into lines, and

how many minutes it takes to reach the street. What is the difference between that wild rush to the stairs many years ago and the orderly arrangement of today? It is merely a matter of discipline. In the three cases of the fire quoted, no fire drills and no systematic means of communicating the breaking out of the fire was attempted or even practised. I certainly agree with Mr. Miller, Chief of Borough of Manhattan, that as bad as the conditions were, panic had a certain amount of force, in the loss of life in the New York Building. Can we eliminate panic? Yes, let me give you two examples taken from the daily papers of New York City.

FIRE DRILL SAVES FORTY-FIVE GIRLS

"A fire drill instituted by the Manhattan Soap Company in its factory, 550–54 West Thirty-sixth Street, immediately after the Asch Building disaster, saved the lives of forty-five girls when a fire starting in the basement yesterday morning roared up through the six stories of the building. The drill was put into use by Miss Barbara Nolan, a forewoman, who has organized it with a few minutes' practice every night after working hours. One hundred men at work in the upper floors got out by the fire escapes, so that no one was hurt, though the building is a total loss. The fire started in the boiler room, and when the engineer, James Vernal, discovered flames among the soap vats on the first floor, his cry sent C. H. Dickinson, the superintendent, and Miss Nolan upstairs to the third floor, where they gave the commands for the drill to the uneasy girls, who filed in good order down the escapes on the west side of the building to the roof of a tinshop next door. From there they reached the street by a ladder. Three girls who went to the wrong side of the building and stood in panic at a window were brought down a long ladder by William Wissel, a firemen, of Truck 5, and Charles Fink, a salesman. Chemicals and grease used in soap manufacture made a blaze of great fierceness that the firemen found it hard to subdue. A second and a third alarm were ordered quickly to save the neighboring buildings. The building was a total loss by the time apparatus arrived in response to the first alarm."

Cool Heads at Factory Fire

"Battalion Chief Owen McKiernan and eight of his firemen were knocked out yesterday by a smoky fire that damaged the three-story building at 2026 Pacific Street, Brooklyn, occupied by the Charles I. Tagliabue Manufacturing Company, makers of thermometers and barometers. Seventy girls employed in the place got out safely, thanks to cool-headed forewomen who formed them into line and led them to the fire escapes. The blaze started in the cellar and when the firemen arrived they found Harry Atwater, the engineer of the building, lying on the floor unconscious. He had been overcome while trying to check the flames with a small hose. While some of the fire-fighters tackled the blaze others helped the last of the girls from the fire escapes. The flames spread so rapidly that the girls had to come down through smoke clouds and many were weak and giddy. The coolness of the forewomen and the fact that the building was provided with large fire escapes on all four sides prevented loss of life. The firemen who got to work in the cellar found that they had an unusually tough job. Men began dropping as soon as they carried in the hose lines and it was necessary for the fire fighters to keep in close touch with each other lest a man drop and be lost in the smoke."

The fire drill is the only salvation to save human life in our factory today. It not only familiarizes the employees with the actual conditions of the exits, aisles and floors, as they are found, but likewise gives a feeling of security as a whole and prevents possible panic. I plead today that the building laws of the United States place the fire drill in the same position as your fire escape, your gong, your red light, your fire proofing, and your unit stress on your rivet. On the walls of your factories you place a certificate of strength, showing just how much the floor will carry. I ask you for another certificate, a certificate of safety showing the character and size of the exit with a proviso that if occupied by a certain number of people, a fire drill shall take place in that factory at least once a week. This should not merely be a perfunctory performance, but should have a penalty like any other violation. The position of the fire drill has not obtained a place in our building law as it should have. It should go with the exits, as the certificate of strength goes with the floor.

I have merely suggested the workings of the "Unwritten Law." Let the makers of our laws differentiate between laws and regulations, making public safety as a whole the object of the former, and structural strength by the bureau the aim of the latter: be wary of clauses giving present structure a long lease of life; give a better classification of buildings, pay more liberal appropriation to bureaus, pay more attention to exits, and place the fire drill in its right position, and you will have gone a long way to curb what I have termed the "Unwritten Law."

PAPER No. 1127

SOME ASPECTS OF THE SUBJECT OF TRANSPORTATION

BY LIEUT. COL. J. E. KUHN,
Corps of Engineers

Read May 3, 1913

In the two decades between 1890 and 1910, the population of the continental United States grew from 63,000,000 to 93,000,000. During the same period the ton mileage of our railroads increased from 65,000 millions to 255,000 millions. Stated otherwise, while the population was increasing 50 per cent., the railroad ton mileage was increasing 400 per cent. To satisfy the demands of traffic in 1890, the railroads of the United States moved the equivalent of one ton of freight a distance of 1,032 miles for each individual. To satisfy the same demands in 1910 it was necessary to move the equivalent of one ton 2,742 miles.

Measured by any yard-stick we choose to apply, we are confronted with the same result, to wit, that traffic and production are increasing much more rapidly than population. Between 1890 and 1912 the production of pig iron, a recognized barometer of business, grew from 8 ½ million tons annually to nearly 30 million tons, an increase of 350 per cent. In the same period the coal production grew from 140 million tons to 550 million tons, an increase of 400 per cent. The manufacture of Portland cement had scarcely commenced in 1890, and amounted to only 1 ½ million barrels in 1895. Last year the production was over 75 million barrels. Between 1889 and 1912 the freight tonnage on the "Soo" Canal grew from 7,400,000 tons to 71 million tons, an increase of 960 per cent. in twenty-three years.

The graphical method is frequently resorted to in engineering questions, for the purpose of determining probable future developments. If we were to plot the curve of population for several decades past, we would obtain a fairly straight line showing an annual increase of about 1.5 per cent. The curves of production

and traffic for the same period would be found to lie above the curve of population, with a strong tendency to escape at the top of the diagram. We may well pause to inquire whither we are going, and how long will the curves of traffic and production continue to rise at their present extraordinary rates. These questions not only present grave problems to the engineering profession, but are also intimately concerned with the present and future social and industrial status of the population.

In seeking for a reason for the greatly increased traffic demands of recent years, we are confronted with the difficulty of distinguishing between cause and effect. Unquestionably, traffic depends upon production and this in turn upon consumption, and we must, therefore, conclude that the increased traffic is the result of greatly increased consumption. But it may be said with equal truth that consumption is limited by production and traffic. In point of fact, all are inter-dependent and must keep pace with one another. The universal application of machinery to the arts and industries has greatly increased human efficiency and multiplied production and consumption manifold, placing within reach of the humblest and poorest comforts and conveniences undreamed of a century ago. New wants are being constantly created, and the luxuries of yesterday become the necessities of tomorrow.

It is related of Diogenes that he lived in a tub, with no other articles of furniture than a lantern and cup. Could we all live as simply as Diogenes there would be no transportation problems. But who wants to be Diogenes? Man these days requires and demands considerably more than the irreducible minimum necessary to provide food, shelter and clothing, and there are no present indications of any disposition to diminish these demands. We may, therefore, confidently expect that consumption, production and traffic will continue to increase in the immediate future, and perhaps for an indefinite time. Whether this condition of affairs is best for the human race is a sociological rather than an engineering question. Its effect on society is, however, plainly apparent in the steady change from an agricultural to an industrial community, in the increase of the urban at the expense of the rural larger cities, with its attendant complex problems of water supply, sewage disposal, intra-mural transportation and sanitation.

In 1890, the rural and urban population stood at 63.9 per cent. and 36.1 per cent., respectively; in 1910, these figures were 53.7

per cent. and 46.3 per cent., and in fourteen states the urban exceeded the rural population. These statistics are based upon an arbitrary classification, towns of 2,500 or less being treated as rural communities. Economic conditions, on which cheap transportation is undoubtedly a large factor, are responsible for the phenomenal growth of cities which have brought us the 55-story building with sub-sub-cellars, networks of street car lines above, on and below the street surface, and stupendous municipal improvements calling for fabulous expenditures. While there is every reason to believe that traffic, production and consumption will continue to increase, there are not wanting signs that there are practicable limits to the growth of cities. Land values and taxation in the large city are becoming increasingly heavy burdens on industries and transportation, and sooner or later must operate automatically to check growth.

Reduced to its simplest elements the problem of transportation is concerned with the transfer of material from one locality to another. Under the influence of gravity such transfer invariably involves the overcoming of resistance, hence calls for the expenditure of energy and the performance of work. Increased efficiency in transportation methods can be secured only by a reduction of resistance or by a cheapening of the cost of the energy employed, and the successive stages of development are due solely to these causes. The primitive men who first discovered and applied rolling friction, or who utilized the buoyancy of water, marked epochs in the history of transportation no less than they who first applied steam and electricity as prime movers. In fact, it may well be questioned whether any event in the development of transportation equals in importance the invention of the wheel, which forms the fundamental basis of all our land transportation. Since the adoption of the wheel all improvements in transportation have been the result of either improved motive power or of improved paths offering less resistance. Animal power has been largely replaced by mechanical power, and the metalled road surface by the steel rail. A freight locomotive moving at an average rate of 15 miles per hour will haul 2,000 tons of freight a distance of 150 miles in 10 hours, equivalent to 300,000 ton miles. A team of horses on the best of metalled roads cannot haul 2 tons more than 20 miles in the same time. To equal the work of the locomotive there would be required 7,500 teams, with an equal

number of drivers. These figures speak for themselves, and obviously make a comparison of operating costs superflous.

In the steam or electrically operated railroad there has been developed a means of land transportation which has enormously expanded traffic, revolutionized industries, and exercised a profound influence upon the social status of mankind. It should, however, not be overlooked that the conditions created by the railroads, like the railroads themselves, are largely artificial. We are accustomed to the belief that the very large modern city is a product of improved methods of transportation, and this is true in a measure, but there are today in China a number of cities with over a million inhabitants, which have managed to get along without the railroad. At the height of her glory, Rome counted 1,400,000 inhabitants, with no other means of transportationt han the packhorse, cart and galley. But neither ancient Rome nor the Chinese cities enjoyed such comforts and conveniences as automobiles, electric lights, furnace heated houses, penny papers, moving picture shows, or the thousand and one other things which make up what we are pleased to call modern civilization. Improved transportation has simply stimulated production and consumption, and with them has produced the conditions which now obtain. The sudden elimination of the railroads from our civilization and a return to the old order would indeed be a calamity. Many persons who have acquired fixed habits would undoubtedly succumb to the shock, but the human race would not suffer extinction. Transportation in some form or other has always been a necessary factor in human welfare, and even in the days of the cart and packhorse amounted to a considerable quantity in the aggregate. What chiefly differentiates modern from ancient methods of transportation is its enormous volume, long haul and concentration.

The Railroads

The United States is preëminently a country of the railroad, and unquestionably owes its phenomenally rapid development to this agency of transportation Of the 650,000 miles of railway line in the world, the United States possesses 244,000, or more than one-third, and is easily first in the ratio of mileage to population, if not in the ratio of mileage to area, in which she is surpassed by the smaller but more densely populated countries of Europe.

In 1910, the railroads of the United States were equipped with 59,000 locomotives 2,300,000 cars, and employed 1,700,000 people in their service. Their outstanding capital was 18,000 millions of dollars, and their gross revenues 2,750 millions of dollars, which amounts to an average annual payment of $30 for each inhabitant for railway transportation. Successive economies in operation and administration, as well as increased volume of traffic, have reduced transportation charges to an astonishingly low figure, which has been maintained for a long period notwithstanding increasing wages, higher priced materials and increased taxes. The average freight rate of 20.9 mills per ton mile which obtained in 1865 fell steadily until in 1888 it reached the figure of 7.7 mills per ton mile, a reduction of nearly two-thirds in twenty-three years Since 1888, the average ton mile freight has remained practically stationary, being given as 7.48 mills for 1911 in Poor's Manual.

The fact that railway management has been able to maintain freight rates in the face of the marked rise in prices of labor and material, and still pay dividends, is no mean tribute to the wisdom energy and ability of the officials.

Since 1890, most of the trunk line railroads have practically reconstructed their systems. Heavy expenditures, both of capital and of surplus earnings, have been invested in reducing curvature and grades, rebuilding bridges supplying heavier equipments and in improving terminal facilities, all of which have conduced to economies in operating expenses and have enabled the railroads to maintain the present low rates. The question of greatest concern to the public at the present moment is whether we may look for a still further reduction of freight rates. On the basis of the traffic reported for 1910, a reduction of 1 mill in the average ton mile freight rate would effect a saving of $255,000,000 annually to the public. In view of the world-wide rise in prices, it seems hardly possible that there will be any material reduction in the cost of railway transportation. In fact, the immediate future threatens an increase of freight rates, as evidenced by a number of applications to the Inter-State Commerce Commission with this object in view.

That further economies in railroad transportation are still practicable cannot be questioned. While we appear to have about reached the economical limit of reduction in train resistance, with our present system of track and rolling stock, there are still pos-

sibilities of considerable economies in the matter of train operation and terminal expenses. In 1880, the average freight train load was only 129 tons. In 1910, this had increased to about 350 tons. Considering the power of the modern locomotive to haul heavy loads, there is still room for considerable improvement in train loads with resultant economy. Further improvement in car capacity in comparison with car weights may also be looked for. At present freight cars have a rated capacity of from 2 to 2 ½ times their weight, which means that even with fully loaded cars about one-third of the train load is tare weight, bringing no revenue. The Norfolk and Western Railway has recently put into service a coal car of 200,000 pounds capacity, weighing 62,500 pounds, giving a ratio of 3.2 of capacity to weight. As indicating the possibilities of train loads, it may be mentioned that about a year ago a single Mallet locomotive hauled a total load of 9,120 tons on the Virginian Railway, of which 6,600 tons was paying freight. The train consisted of 120 loaded coal cars containing 55 tons each, and the haul of 120 miles was made at an average running speed of 15 miles per hour.

In general the larger the container, the greater the proportion of the net weight of contents. Unfortunately, limitation of clearances and stability with the present gauge have placed a limit upon the height and width of cars, and the increase of but one linear dimension will not have any very marked effect in improving the ratio between net and tare weights of freight car loads. In this connection it is open to argument whether a broader gauge than standard, permitting the use of larger cars and heavier loads, with shorter trains, would not afford more economical transportation. Were it a matter only of long haul through traffic, there could be no question as to the superiority of a broader gauge, but considering transportation as a whole, the unsuitability of unduly large equipment for feeder lines and the advantage of an interchange of cars, the present standard gauge is perhaps not far wrong.

In the matter of efficiency of freight car equipment, much remains to be desired. In 1890, statistics of 1,000,000 freight cars in service showed that the average daily distance moved was only from 17 to 25 miles, a two hours' run. In a recent article by the General Superintendent of Transportation of the Illinois Central Railroad, there appears to have been but little improvement in

this particular, the average movement of all freight cars on that line being but 27 miles per day. The records showed that as an average for each month, 13 days were spent in loading and unloading, 3½ days in moving, and 13½ days standing. Even a slight increase in the daily car mileage would result in large economies, both in first cost of equipment saved, and increased revenue from equipment in use. This is a question of operation and terminal facilities, which constitute the chief fields for the practice of further economies. In comparison with haulage charges the terminal freight charges in large cities are unduly high. Congested freight stations, antiquated methods of loading and unloading cars and high cost of land are laying a heavy embargo on transportation to and from the largest cities. To remedy these conditions will call for heavy expenditures, but unless terminal facilities keep growth with the ever increasing volume on tonnage the traffic capacity of the railroads will soon attain its limit, and this long before track capacity shall have been reached. Since 1890, railroad mileage has increased 50 per cent., while the ton mileage has increased 400 per cent., and the density of traffic is susceptible of still further increases, but only on condition that freight terminal facilities and the efficiency of freight equipment be increased correspondingly.

Whether we may ever expect any radical change in track construction is problematical. Systems of construction like the mono-rail, overhead and gyroscopic, or the sliding railway exhibited at Paris in 1889, afford promising possibilities in the way of reducing tractive resistances, but the cost of their installation has so far prevented any economical results. The question of a change of motive power, from steam to electricity is an open one. For city terminals electricity has certain advantages which have led to several notable installations, and there are indications of its extension to main line traffic where hydro-electric plants offer attractive rates for power. For the time being the question of electricity or steam is more a question of convenience than of economy, and we may expect the steam locomotive to hold its own for some time in the future. To sum up railroad transportation, further improvements in haulage costs will probably not be material, but in the matter of operation and of terminal charges there is still room for important economies.

Motor Vehicles

About fifteen years ago the automobile made its first appearance upon the streets of our cities as a practicable pleasure vehicle. Today over one million machines are hurrying and scurrying through the highways and byways of our vast land. As a pleasure vehicle, the automobile has practically displaced the horse-drawn carriage, not because it is a cheaper form of transportation, but because one can go farther and faster and have more fun. While the large number of pleasure cars has not been without some effect on passenger transportation, especially intra-mural and suburban, this has been small in comparison with the volume of the business, and merits no further consideration.

Within a very few years, however, the self-propelled vehicle has been applied to uses other than pleasure, and promises to become a real factor in the transportation problem. I refer to the rapidly increasing adaptation of the motor truck to commercial uses, which greets one on all sides in and about our larger cities. The mere fact that progressive merchants, manufacturers and contractors, to whom the question of dollars and cents is of paramount importance, are committing themselves to motor trucks for delivery and haulage purposes is sufficient evidence of the economical advantages over horsedrawn vehicles.

Motor trucks are now manufactured with capacities up to 10 tons, and by suitable modifications of their bodies are adapted to a wide range of special services. Greater loads and greater speeds have established conclusively the economy of the motor as compared with the team for all classes of city and suburban delivery where good roads are available. Under favorable conditions a heavy truck will negotiate 300 to 400 ton miles per day, as much as 7 to 10 teams of horses. A prominent maker of motor trucks claims a cost of 4 ½ cents per ton mile as compared with 11 cents for teaming.

Although motor truck transportation is still in its infancy, it has already assumed formidable proportions. Many manufacturers of pleasure cars have added commercial cars as a branch of their business, while other concerns limit their output entirely to this class, and all are prospering. Aside from its already established advantages as a means for delivery and haulage within cities and their immediate suburbs, there are other possibilities

for the motor truck, some of which have a direct bearing on the general problem of transportation. A motor truck can be handled with much more certainty in cramped quarters than can horse-drawn trucks. This will enable them to run directly into shipping and packing rooms to receive or discharge their loads, without the necessity of trucking. By porper arrangements at freight receiving and delivery stations, motor trucks can be run directly alongside freight cars, and trucking saved at this point likewise. The reduction or elimination of trucking charges will go a long way towards reducing terminal charges which form so large an element in transportation costs.

Another use for the motor truck is in the direct haulage of freight over considerable distances, cutting out intermediate railway haulage. Such direct deliveries will save rehandling and often packing, and where the distance is not so great, but what the truck can return to point of origin the same day, may afford as economical a service as the railway, as well as a speedier one.

A necessary adjunct of motor vehicles in their present state of efficiency is good roads. Without good roads the motor vehicle loses all its advantages over the horsedrawn vehicle. In comparing transportation cost by motor truck with other forms, the cost of constructing and maintaining good roads should be charged, in part at least, to the motor truck. Since the advent of the automobile there has been a widespread popular movement for improved highways, and vast sums have already been expended on this account, while still larger expenditures are in contemplation. In both first cost and in maintenance the character of highway demanded for motor vehicles is much more expensive than appropriate for wagon traffic. High speed passenger and heave commercial cars are very destructive to ordinary road surfaces and the increased cost both of construction and maintenance should be charged against this new form of traffic, instead of being borne by the general community.

Until there is a vastly great mileage of improved highways, we may expect the field of the motor truck to be limited to the larger cities and their immediate suburbs, and in this field it has abundant possibilities for development. In Europe with its network of excellent highways and dense population there is a better field for the motor truck outside of city limits, and this form of transportation has consequently made greater progress than in

the United States. In both France and Germany the motor truck has already largely displaced the baggage wagon for the supply of armies in the field. Experiments along the same line in the United States have proven less reassuring, owing to poor country roads and weak bridges, and the passing of the army mule is still for the future.

Water Transportation

On a good macadam road a team of horses can move 4 tons; on a track laid with steel rails the same team can haul 10 tons; hitched to a canal boat it can haul 200 tons. In other words, at low speeds, the tractive resistances of water-borne loads are approximately one-twentieth of those on a steel laid track. With such an advantage in its favor, it may well be asked: Why has not water transportation held the field against all other forms? Notwithstanding that, in certain European countries, canals and rivers are still important as transportation routes, and it is a fact that in the United States inland navigation, with a few notable exceptions, it is not only languishing, but has almost suffered extinction. In spite of generous and persistent appropriations by a paternal government for the improvement of rivers and the construction of canals, navigation has failed to respond, and the yearly returns indicate a declining tonnage. Of the numerous state canals built between 1820 and 1840, all have succumbed save the Erie, and its traffic has not kept pace with the growth of the country. It has not infrequently been charged that the decline of our inland water transportation was brought about by the deliberate machinations of the railroads. While we may safely assume that there is no love lost between rivals in business, it is inevitable that in the final analysis, the survival of the fittest will be determined by economical considerations alone. The triumph of the railroad in competition with the early canal is due solely to the fact that the former proved itself a better all around agent of transportation. There are a number of reasons to account for this, among which the following are the more important.

1. The greater adaptability and flexibility of the railroad to meet the wants of transportation, and its relative independence of topographical consideration as compared with water routes, which must follow more or less available natural water supplies.

This enables railroads to be located so as to go after existing or potential traffic where a water route would be economically impracticable.

2. Railroads can bring their transportation facilities to the very doors of industries by running switches into factories and warehouses, thus eliminating cartage charges. To secure the same advantages with a water route the industries would have to be located upon the edge of the channel, where foundations are sometimes troublesome and where flood damages are liable.

3. The greater reliability of railroad service, which is not subject to flood and ice interruptions, such as frequently occur on water routes.

4. The superiority of the railroad for passenger traffic and express business in the matter of speed and in the ability to haul freight long distance without breaking bulk.

In the matter of actual economy it has been demonstrated that under favorable conditions the railroads can haul coarse commodities like coal and ore at a rate as low as 4 mills per ton mile, with a profit. Such a rate will compare favorably with water rates on restricted channels, either artificial or natural. In order to realize the potential economy inherent in the low tractive resistance of water borne loads, channels of ample cross-section, permitting the use of large boats at fair rates of speed, are needed. Such channels must not only provide a margin of depth over draft to allow for the "squat" of the boat when under way and to obviate the "drag" which results when the hull is too near the bottom, but also ample width to reduce wave wash and consequent damage to the banks. Observations recently made on the upper Hudson indicate that the squat of a boat under way is a function of the speed and depth of channel. In the case of the "Hendrick Hudson," a steamer 400 feet long and 9½ to 10 feet draft, the observed squat in water 135 feet deep at 22.5 miles per hour was .99 foot; at 11.5 miles per hour in the same depth the squat was only .15 foot. In water 14.4 feet deep the squat was 1 foot at 9.14 miles per hour, with a squat of over 3 feet. The effect of drag is to increase the power required to drive the boat at a given speed, as well as to limit the speed if channel depths are insufficient. The swell likewise is a function of depth of channel and speed of boat. In the case of the "Hendrick Hudson," the swell when running at 22.5 miles in water 135 feet deep was about 1 foot, and

its effect inappreciable at a distance of 1,000 feet. In a channel 770 feet wide and 12 feet deep, while running at 11 miles per hour the swell at the shore measured 5.5 feet from hollow to crest. Ordinarily the provision of purely artificial channels of adequate dimensions to permit of free and easy navigation will involve so large a capital outlay as to make economical returns without a very large volume of traffic. Comparisons of rail and water rates are frequently misleading for the reason that no account is taken of the capital charges against the cost of channel improvements when these improvements are made at the expense of National or State Governments. A correct analysis of transportation charges on existing water routes in which capital and operating charges are included will reveal the fact that water rates are often higher than railroad rates. Government expenditures on water routes are not infrequently supported by the plea that even if they do not develop a traffic that will show returns, they serve the public indirectly by acting as a corrective on exorbitant railroad charges. Granting this to be true in certain cases, it would appear that a more certain and less expensive method for correcting railroad rates might be devised.

In Europe inland water transportation makes a better showing than in the United States, and water-borne traffic is still a factor in internal commerce. This is accounted for, partly at least, by the fact that in European countries centers of population and of industry were located on available water routes long before the advent of the railroads, and that trade accustomed itself to this mode of transportation. When the railroads made their appearance in the United States much of the country was still an undeveloped wilderness. The new agent of transportation with its flexibility and independence of topographical conditions permitted the establishment of towns and industries without reference to water routes, and at points where water transportation is economically impossible. The shorter hauls and denser populations of European countries also favor water transportation. Germany, with 200,000 square miles and 65,000,000 people has one mile of railroad for each 1,600 population, as against one mile for each 400 in the United States. But even in Europe many of the old time canals are failing to show economic returns and are experiencing a declining traffic.

The fact that haulage charges are admittedly lower by water

than by rail, and the phenomenal success of certain notable water routes is no doubt largely responsible for the popular fallacy that transportation by water is always cheaper than by rail. Unfortunately, haulage charges do not constitute the sole factor in the cost of transportation, and not always the largest part thereof. In average country a single track railway 100 miles long can be built and equipped for about $5,000,000. A canal of equal length, with single locks adapted for 300-ton barges, will cost about twice as much. On the assumption of one boat locked up and one locked down every hour for every day in the year, a fair assumption for a canal of this type, we secure the maximum traffic capacity of 2,500,000 tons per year. With sidings every 15 miles the railroad can handle 5,000,000 tons per year. To meet capital charges at 5%, the canal would have to charge 2 mills per ton mile, as against ½ mill per ton mile by the railroad. For such commodities as are suitable for canal transportation, the difference of 1½ mills per ton mile to cover capital charges will go a long way towards meeting any difference in haulage cost in favor of the canal.

No more convincing evidence of the inability of the small canal to compete economically with the railroad could be afforded than the present state of decadence of the many canals constructed in the United States shortly before the advent of the railroad. The Morris, the Lehigh, the Schuylkill, the Delaware and Raritan, the Delaware and Chesapeake, the Chesapeake and Ohio, and many others of like character have all succumbed to the competition of the railways. The Morris Canal, chartered in 1824 and completed in 1836, was built to carry anthracite coal to tidewater at New York, a distance of 107 miles, and designed for a maximum annual capacity of 1,000,000 tons. It passes through difficult country, surmounting an elevation of 900 feet above tide water by means of 22 inclines and 30 locks. The boat of 70 tons capacity, built in two sections for separation at the inclines, took 5½ days to make the journey to Jersey City. Although a triumph of engineering, it is little wonder that this canal was forced out of existence by the competition of the railways, three lines of which parallel the canal, each line with an annual traffic capacity of 10,000,000 tons, and capable of hauling train loads of 2,000 tons in 5 hours.

While small canals of the type in question are no longer capable

of holding their own against the railroads, it must not be overlooked that their construction for the most part antedates that of their rival, and when undertaken they were a great advance upon transportation by the ordinary highways, and that they played no small part in the development of our country. Of all these earlier canals the sole survivor as a transportation factor is the Erie, whose resuscitation is now being undertaken by the State of New York at an expense of some $130,000,000, so as to permit of traffic by barges of 1,000 tons capacity on a depth of 12 feet. It is expected that this will result in a canal rate of 2-3 of a mill per ton mile, a rate beyond the possibility of competition by the railroads. It remains to be seen whether the hopes of the supporters of the enlarged Erie Canal will be realized. As a connecting link between the commerce of the Great Lakes and the Atlantic seaboard the canal has tonnage possibilities which may justify the expenditures involved through savings to the public in transportation charges, but it must not be overlooked that at 4% these savings should be $5,200,000 annually to cover capital charges. Evidently the tonnage must be heavy to effect such a saving. Whatever opinion may prevail as to the wisdom of the present project for enlarging the Erie Canal, the original canal was a fortunate and profitable undertaking, and contributed largely to the commercial supremacy of New York. Until the close of the Civil War the canal tonnage exceeded that of the competing railways, but after that it fell hopelessly behind, not so much because of a decline of tonnage on the canal, as because of the enormously rapid growth of the railway tonnage.

Transportation by water is subject to the same economic laws as any other method of transportation, and may or may not be more economical than rail transportation. Given ample natural waterways and an ample tonnage, water transportation will show an economy far beyond that of the railroad. A natural water route offers a free right-of-way without capital or maintenance charges, and gives the water route an advantage which the railroad cannot possibly overcome. An example of a successful inland water route is that of the Great Lakes, which afford over 800 miles of navigation from the head of Lake Superior to the foot of Lake Erie, obstructed only at the rapids of the St. Mary's River and at the narrows of the St. Clair and Detroit Rivers. Favored by ample channels and by an enormous tonnage of coarse

freight, such as ore, coal, grain and lumber, the commerce of the Great Lakes has advanced by leaps and bounds in a manner truly impressive. In 1883, the tonnage at the Sault Canal was reported at 2,267,105 tons. In 1912, the canal handled over 70,000,000 tons, a more than 30 fold increase in 30 years. Practically all the tonnage in the Sault Canal is through freight between upper Lake Superior and lower Lake Erie points, and is hauled nearly 800 miles. Reduced to a ton mileage basis, the freight locked through the Sault Canal in 1912 represents 56,000,000,000 ton miles of traffic, nearly one-fourth the total ton mileage of all the railroads in the United States in 1910. Huge as this tonnage may be, it does not cover all of the Great Lakes traffic, as it takes no account of tonnage between Chicago and lower lake ports, nor of tonnage between local points. This enormous traffic is carried on during but 7½ to 8 months of each year, navigation being stopped by ice for the remaining months.

The growth of the Great Lake traffic has been so rapid as to seriously tax the ability of the Government to provide the needed facilities, especially lockage facilities at the St. Mary's River. In 1855 the State of Michigan completed the first locks, two arranged tandem, each 350 feet long and 70 feet wide, with 9 feet lift, thus opening a 12-foot navigation on the Great Lakes and connecting waterways. In 1870 the Federal Government entered upon a project for a 16-foot navigation, including a new lock 515 feet long and 80 feet wide, with a single 18-foot lift. This lock, known as the Weitzel lock, resulted in so rapidly increasing traffic that in 1886 a project for a 20-foot navigation and a new lock on the site of the old State locks, measuring 800 by 100 feet, was entered upon. The new lock, known as the Poe lock, was completed in 1896.

In 1907, a project for a still larger lock with a separate canal approach, to measure 1,350 by 80 feet, with 24½ feet of water on the sills, was adopted, to be followed in 1912 by a project for an additional lock of the same size. The last two locks are now under construction.

During the season of 1911, 20,242 vessels were locked through the American and Canadian canals in a total of 14,347 lockages. An average of 78 vessels daily passed the locks throughout the season of 237 days of navigation.

The continued improvement of the Great Lakes waterways has

been accompanied by a continued increase in the size of the lake boats and a reduction in freight rates. In 1859, the largest vessels averaged 700 tons net register, with the 12-foot draft available. In 1890, when the 16-foot navigation had been finished, the average net registered tonnage of the large vessels had grown to 1,500 tons. With the present 20-foot navigation the largest vessels carry cargoes of 8,000 to 10,000 tons. In 1890, the average lake freight rate was 1.5 mills per ton mile; in 1912 it was reported at .67 mill per ton mile. These rates, of course, do not include capital charges, on account of improvements of the waterways, which are a gift of the Government. So large is the traffic, however, that the inclusion of capital charges would not increase the freight rate materially.

The astonishingly low freight rate on the Great Lakes is the result not only of the potential economy of water transportation, but also to the development of special transportation facilities for a more or less special transportation service. The bulk of the freight consists of ore, coal and grain, commodities which can be quickly loaded and unloaded, thus reducing terminal charges. Coal and ore chutes, car unloaders, hoisting and conveying machinery and numerous hatchways enable the lake carriers to take on or discharge cargoes with remarkable speed, so that little time is lost in port. Such a combination of favorable conditions as obtain in the transportation business of the Great Lakes is, of course, unusual, and the low freight rates are in consequence exceptional.

The mere existence of a natural water route is of itself no guarantee of an economical transportation service. Unless the route has traffic possibilities, it cannot show economic returns. The great volume of the traffic of the United States has for years moved, and still moves, on east and west lines. While the traffic of the Great Lakes is increasing yearly, that of the Mississippi River and its tributaries is at a standstill. Aside from obvious physical difficulties, due to floods and shifting channels, the direction of the river crosses the main arteries of commerce, and this of itself is a sufficient handicap to prevent the realization of the dreams of the waterways enthusiasts, who for years have been agitating a 14-foot channel from the Lakes to the Gulf, with ocean-going steamers tied to the banks. Fortunately, wiser counsel appears to have prevailed, and the danger of the Government committing

itself to such a monumental economic error as a 14-foot channel has been passed for the time being. Why a depth of 14 feet should have been selected by these enthusiasts is difficult to understand, for it is suited neither to ocean nor Great Lakes traffic. While depth is always desirable, especially for ocean or lake steamers, economical transportation is possible with depths considerably less than 14 feet. The Mississippi River now and for some time has afforded a 9-foot navigation from its mouth to Cairo, 8 feet to St. Louis, and 4½ feet to Chicago. With practically the same depths, the Rhine enjoys an annual traffic of 54,000,000 tons by means of tows of barges. The barge of from 500 to 1,000 tons, with suitable towing boat, affords about as economical a system of transportation as any that has yet been devised, and if there are any traffic possibilities in the Mississippi River there is sufficient depth available to permit of their realization. Until the present possibilities have been exhausted it would be the height of folly to expend huge sums in securing greater depth, certainly not a depth of 14 feet, unsuited alike to either ocean or lake carriers. What is more important than a deep channel from Chicago to the Gulf is a channel of more moderate depth which can be developed not only on the Mississippi, but also on its main tributaries, and the development of a system of navigation by carriers adapted to that depth. A depth of 9 feet will afford economical transportation by tow boats and barges, and this depth is already available on the Mississippi from the Gulf to Cairo, and is being provided in the Ohio by a system of canalization. With reasonable expense this depth can be carried to Chicago via the Chicago Drainage Canal, and in this way a system of internal waterways placed at the disposal of the public sufficient for a long time to come. Whether such a system will ever prove economical from a business standpoint is doubtful, but until traffic justifies, no greater depth than 9 feet is warranted.

In the United States the railroad has unquestionably won out as the chief agent for inland transportation, by giving better service as well as frequently the most economical when all factors are included. This does not mean that water transportation is doomed. Under proper conditions, and within limits, water routes are economical agents of transportation, and with increase of population and of traffic the field for inland water transportation will increase rather than diminish.

Ocean Transportation

On the ocean water transportation attains its greatest economical development. Large carriers, long hauls, and mechanical power for driving the ship and for loading and unloading cargo have brought ocean freight for bulk commodities to as low a figure as ½ mill per ton mile. With the growth of the world's traffic, ocean tonnage has increased enormously, steam has replaced sails, and the size of carriers has increased tremendously. For 1911, the value of international trade is given at 30,000 millions of dollars, nearly all of which was carried in ocean bottoms. The share of the United States in this international trade amounted to 4,000 millions of dollars, or more than one-eighth. In all countries there is a record breaking activity in shipping and in ship construction, taxing shipyard and harbor facilities to the utmost. The growth of ocean traffic is but a reflection of the world's activities, and, as in the case of railroad transportation, the national response to increased consumption and production.

The item of chief interest in connection with ocean traffic is the size of the ship and whether there will be any limit in this direction. Upon this item depends the planning and carrying out of the costly works of harbor improvements now going on in all quarters, including both channels and docks. Not only have ships' dimensions been increasing, but during the last few years this increase has been at an accelerated rate. Up to 1900 the largest steamship, typified in the "Oceanic" of the White Star Line, had a length of 685 feet, a gross tonnage of 19,000 and a load draft of 30 feet. Since then the increase has been by leaps and bounds, culminating in the "Imperator" of the Hamburg-American Line, now about to make her maiden voyage, 880 feet long, 50,000 gross tons, and 34 feet load draft. A still larger vessel, the "Vaterland," 950 feet long and 150 feet beam, has just left the stocks. So far as mere construction is concerned, there is no reason why the already large dimension of ocean leviathans may not be considerably increased. The structural materials now available, and the introduction of the turbine engine, without counting on further improvements, have not yet placed a bar on further increases of dimensions. So far as the shipowner is concerned, his interests lie in the direction of larger ships, not only

because of the fundamental economy in propulsion and the ability to attain increased speeds, but because of certain other advantages, among which may be mentioned:

(a) Ability to maintain high speed in rough weather.

(b) Greater steadiness and comfort to passengers.

(c) Better and more spacious passenger accommodations.

(d) The business attraction incident to having the largest, fastest and finest boats.

Up to a certain point an increase of size is unquestionably advantageous in the interests of steadiness and sustained sea speed. What this point is depends upon the size of storm waves and, judging by performance, is attained on the Atlantic by vessels in the express service of the great steamship companies, such as the vessels "Mauretania" and "Kaiser Wilhelm II," 700 to 750 feet long, and 30 feet load draft. Vessels of this type develop a speed of from 23 to 25 knots in all weathers, and maintain a regularity of service comparing favorably with the transcontinental express trains. Larger dimensions than those just quoted cannot be justified on the grounds of steadiness and sustained speed, and the latest dimensions attained in the "Olympic," "Imperator" and "Vaterland," owe their adoption to other causes, probably to the desire for increased passenger accommodations and for notoriety.

If, then, there is to be any limit to the growth in size of ships, it must be sought for in causes outside limitations of construction and ambitions of ship owners. Such a cause is found in the limitations of draft imposed by existing physical conditions in most of the seaports and harbors of the world. That this cause has already exercised an influence in the dimensions of ships is evident from the manner in which ships have grown, the increasing being mainly in length, breadth and molded depth, with relatively small increase in draft. Since 1900 the largest vessels show an increase of 35% in length and breadth, as compared with only 10% to 12% in load draft. The reason for this is obvious. The provision and maintenance of very deep approach channels, often of great length, and of deep water docks, impose expenditures and difficulties so large that even well intentioned government and port authorities may be excused for taking a reluctant attitude. That the demands of ship owners have been met in a generous spirit is evidenced by the costly works of harbor improvement now under way

in all parts of the world. Staggering sums are being expended at the present time to provide accommodations for the large ships now in use, and one needs only to consider the vast engineering works at Bremen, Hamburg, Liverpool, London, Havre, New York, Buenos Aires, and other world ports to realize the obligations that have been imposed by the increased dimensions of vessels and the growth of the world's traffic.

It is not only in the matter of deeper and more commodious channels required, but also in the enlarged port facilities that the very large ships of today are giving concern. The piers, dry docks, wet docks, and quay walls to accommodate these ocean monsters are exceedingly costly, and must eventually operate to limit growth in size if consideration be given to economical returns. Hitherto the extraordinary growth of the world's commerce has enabled costly port works to be carried out under conditions which have either actually shown economic returns or have been considered justified by governments on the ground of general benefits, regardless of returns on capital expenditures. If, however, ships continue to increase at the present rate, it is certain that a point will be reached beyond which port and governmental authorities can not go in the matter of providing accommodations. It may well be questioned whether we have not already reached a point where capital charges for channel and port improvements do not exceed the economies resulting from carriage in large ships.

As a matter of fact, the costly harbor accommodations now being provided serve relatively few ships, engaged in special service and plying between great centers of commerce and population. The great bulk of the world's carrying trade is still carried in ships of relatively modest dimensions, and not requiring excessive channel depths. An examination of the British register of merchant vessels for 1910 shows out of a total of 11,500 steel ships above 100 tons gross register, only 328 exceeding 7,000 tons, and only 20 exceeding 15,000 tons. It is these very few large vessels, carrying an insignificant part of the world's commerce, which has forced the huge expenditures which are now being undertaken for port improvements. It looks very much like a case of the tail wagging the dog.

The fact that we have the very large and fast steamers on our hands must be taken as prima facie evidence that their owners expect economical returns, either directly or indirectly. It must

not, however, be overlooked that the express steamers of the great European steamship companies are in receipt of considerable subsidies from their governments. The "Mauretania" and "Lusitania" not only receive an annual subsidy of $750,000, but were built by a government loan of $13,000,000, at the low rate of 2 3-4%, payable in 20 years. It is also noteworthy that a speed limit appears to have been reached in the case of these vessels, and that the latest additions to the roster of ocean giants are designed for slower speed and a larger cargo capacity, the latter feature being largely sacrificed in the fastest express boats. Where national prestige and national expenditures are concerned, as in the case of the building of large ships and the providing of berthing accommodations for them, economic considerations are often thrown to the winds. Demands of ship owners and rivalry of ports still further cloud the economic aspects of ocean traffic. But, in spite of all the factors operating to increase the size of ships, we may conclude that there is a limit to their growth, and that this limit, moreover, is not far from having been reached, due to limitation in channel drafts and to harbor facilities.

The cost of dredging increases rapidly with increase of depth, not only because of the greater lift and reduced output of excavating machines, but also because at the greater depths harder material is encountered. What the addition of one foot in depth means in the case of a channel like that of the Delaware River is shown by the fact that for each additional foot of depth 10,000,000 cubic yards of original excavation must be made, costing at present average prices $1,500,000. At the depth now being sought, viz.: 35 feet, the familiar Delaware River mud is changing to gravel, hardpan, cobblestones, boulders and some ledge rock, and unit prices are increasing. Much of the dredging-machinery now in use was not designed for work at such great depths as now required, and cannot be employed in all places. Some of the dredges now at work in the Delaware cannot dig at high tide, their booms and ladders not being long enough to reach bottom. Not only does the cost of dredging increase rapidly with depth, but also the cost of wet and dry docks, piers and quay walls. For the present 40 feet appears to be the limit of channel depth contemplated, a depth which has now been provided for New York Harbor, the Panama Canal, and several European ports. This depth provides

for the largest vessels now afloat or building, and leaves some margin for future increase.

In this country it is the policy of the National Government to provide the necessary approach channels to ocean ports and to fix the harbor lines beyond which encroachments by riparian owners is forbidden in the interests of navigation. Until very recently the development of port facilities has been left to the several riparian owners without any central or general control. In Europe and elsewhere a different policy generally prevails, the administration of the port as a whole, including the provision and maintenance of approach channels, being in the hands of a single body, a Board or Commission invested with the needful legal authority and deriving its funds from the sale of bonds, aided by contributions from the States and municipalities. Charges are made for the facilities offered, and the revenues so derived are applied to the maintenance and improvement of the port and to pay capital charges.

The principal requirements of a successful ocean port are:

1. An approach channel of ample dimensions.
2. Ample dockage facilities.
3. Warehouse space.
4. Freight handling machinery.
5. Facilities for coaling and repairs.
6. Railroad connections.
7. A hinterland affording traffic possibilities.
8. Low port charges.
9. A unit control for the management and development of the port facilities.

Port administration as heretofore practiced in the United States has been characterized by haphazard methods and a general lack of any definite policy looking to future growth and development, Out of some 50 principal coast and lake harbors, only two, San Francisco and New Orleans, are at present adequately administered by a single authority operating under State laws. While other ports, like Boston, Philadelphia and Baltimore, have duly legalized port authorities, their usefulness is greatly curtailed by the fact that the greater part of the water front property is owned and controlled by private and corporate interests, mainly the railroads. Where such conditions prevail it is too much to hope that these interests will voluntarily improve their property in

accordance with any general policy looking to the benefit of the port as a whole, even when such a course will ultimately redound to their own advantage. Nothing short of the exercise of eminent domain and the acquisition of water front property by municipalities or states will ever result in a systematic port development. Such port facilities as we now find at most of the harbors in the United States are due mainly to the railroads, which have constructed piers, tracks, elevators, coal and ore chutes, and other special structures to meet the requirements of their individual business, and which are generally free to vessels taking on or discharging cargo handled by the road. The generous attitude of the railroads towards vessels is made possible, of course, only by the absorption of the overhead charges for the terminal in the railway freight rate.

In the matter of approach channels, a minimum depth of 35 feet at mean low water may be regarded as essential to the requirements of an ocean port. This does not mean that a vessel can load to this draft, for she must needs have some clearance under her keel to allow for "squat" when under way, and to provide a margin for extraordinary low tides, which may fall two feet below the mean under certain directions of the wind. About 32 feet load draft is the maximum which should be attempted in a 35-foot channel at mean low water, and this is sufficient for the largest cargo steamers now in service. Of the competing ports on the North Atlantic seaboard, Montreal has a 30-foot channel, Boston 35 feet, New York 40 feet, Philadelphia 30 feet, with a 35-foot channel under way, and Baltimore 35 feet.

Boston's 35-foot channel is 7½ miles long and cost about $9,000,000; New York's 40-foot channel is 7 miles long, and cost about $5,500,000; Philadelphia's 35-foot channel is nearly 60 miles long, and will cost about $11,000,000; Baltimore's 35-foot channel is 24½ miles long, and cost $3,500,000. Large as these expenditures for deep approach channels may appear, they are justified by the heavy and constantly increasing tonnages. New York's port tonnage for last year, including both foreign and coastwise, amounted to about 200,000,000 tons; that of Philadelphia to 25,786,000 tons; and of Baltimore 10,123,355 tons. Boston's foreign tonnage alone was 12,258,000 tons in 1911, with probably three times as much more in coastwise tonnage. In view of the heavy ocean traffic, large expenditures for ample channels at our

ocean ports need no defense, and are much wiser than those made in the fruitless attempt to develop internal traffic on our river systems.

In the United States vessels are almost invariably docked at piers extending more or less at right angles to the approach channels. The more commodious water areas available in the United States ordinarily admits of this course, where in Europe, vessels are locked into basins at one side of the channels and made fast to quay walls. Piers must be at least as long as the vessels they are to accommodate, and with the constantly increasing dimensions of ships, the encroachment of the longer piers in channel widths is becoming a serious matter. This question is giving New York Harbor serious concern at this moment, the Secretary of War having declined to permit of further pier extensions in the Chelsea district, where all the large express steamers dock. Piers mustal so have ample width to provide for the accommodation of cargo and passengers, the latest constructions showing widths of 300 feet. Slips separating piers should be not less than 150 feet wide, so that two vessels may lie in the same slip and still have space between them for lighters to come alongside.

In foreign ports much attention is devoted to freight handling machinery, to enable cargoes to be handled with dispatch. Traveling cranes, shear legs and like appliances are installed to handle package freight. In the United States little has been done in this direction save for handling bulk freight, like grain, ore and coal. At Boston, the Boston and Albany Railroad has a grain elevator designed to deliver 10,000 bushels of grain per hour to each of four hatches simultaneously, by a system of belt conveyors operated electrically. The elevated coal and ore pockets commonly in use enable a vessel to take on 7,000 or 8,000 tons in four or five hours. Since unnecessary delays in port are prejudicial to the interests of the port, it is important that docks be provided with the best and most rapid loading and unloading appliances, to enable vessels to make quick returns.

As most ocean freight is transit freight, it is of course important that terminals should have rail connections. The best results are obtained by tracks running directly on the pier and close alongside the ships' hulls, so that freight can be transferred directly between ship and car. Where several railroads and several docks serve the same port, a belt or connecting railway is essential.

Low port charges are necessary to attract trade, and any discriminations in this respect will injure the business of a port. As already mentioned, vessels using railroad owned terminals ordinarily pay no wharf charges when their cargoes are handled, in whole or in part, by the railroads, the use of the piers being free to the vessel, and being treated as an incident in the business of the railroad. In Philadelphia, independent pier owners make a charge of 1½ cents per ton per day for steamers and from 3-4 to 1 cent per ton per day for other craft, based on net registered tonnage. The railroads do not even charge for freight delivered over the vessel's side into barges or lighters and destined for other points in the harbor, nor is any charge made for freight consigned locally and hauled away in trucks or drays. Freight not removed in 4 days is subject to a storage charge of 5 cents per 100 pounds for each 30 days or fraction thereof. Somewhat similar conditions obtain with railroad owned terminals at Baltimore and Boston. Other charges to which vessels using the port of Philadelphia are subject are the tonnage tax, pilotage, and tugboat service. The tonnage tax is a Federal tax, amounting to 2 cents per registered ton on vessels from Canada and the West Indies, and 6 cents per registered ton for vessels from other foreign ports, collected on five trips or less per year. From $150,000 to $200,000 is collected annually in tonnage taxes at the Port of Philadelphia.

Pilotage is charged at rates authorized by state laws, and amounts, roughly, to $5 per foot of draft. Tugboat charges are in accordance with schedule adopted by the Towboat Owners' Association, and vary with the carrying capacity of the vessel. For a vessel of 5,000 tons capacity, the towage charge between Philadelphia and the Capes in $165 inbound, and $312 outbound. For docking steamers two tugs at $15 each are charged.

The foregoing scales of charges to which vessels are subject prevail with small differences at Boston and Baltimore also. In New York many of the piers are municipally owned and rented to steamship companies. The Cunard and White Star Lines pay something like $70,000 annually per pier rented. The question of adequate port facilities is one of peculiar interest to Philadelphia, for the reason that her port is in keen competition with several rivals for a share in the ocean trade of the North Atlantic seaboard, with its rich hinterland and heavy export and import tonnage. Montreal, Boston, New York, Philadelphia, and Bal-

timore are all in the race, with physical advantages so nearly balanced that any neglect on the part of those responsible for the port's development will surely lead to a decline of traffic. Trade is conservative, and once lost it is hard to recover. New York, with its 40-foot approach channel and the advantage gained early in the competition through the Erie Canal, has won a position from which she cannot well be dislodged. A commodious harbor, steamship lines to all parts of the world, and ample railways to the hinterland have secured her supremacy as the premier port of the Atlantic seaboard.

In the matter of distances there is little difference between the competitive ports under consideration. The distance from Chicago to Liverpool by the five ports varies from 3,813 miles via Montreal to 4,153 miles via Baltimore, a difference of but 340 miles. Baltimore is the nearest to Chicago and Montreal the nearest to Liverpool. With approach channels and distances so nearly alike, and with practically equal rail connections to the hinterland, it will be readily seen that there is little to choose between Montreal, Boston, Philadelphia and Baltimore, save in the matter of port conveniences and facilities.

Montreal is an example of a systematic and logical development of a seaport made possible by the fortunate circumstance that she retained the ownership of her water front. The city not only builds and owns all the docks, but also the grain elevators and all track connections with railroad lines. A sufficient revenue is derived from switching charges, handling grain and rental of privileges to pay maintenance and operating expenses and interest on bonds, without charging the ship any wharfage. Unfortunately, the example of Montreal cannot well be followed by either Boston, Baltimore or Philadelphia, for the reason that neither city owns but a small percentage of the available water front.

The duly constituted port authorities of both Boston and Philadelphia are active in providing municipal terminals and in endeavoring to build up the business of their respective ports so far as their means will permit. Aided by a State loan of $9,000,000, the Directors of the Port of Boston have recently completed two piers, each 1,200 feet long and 300 feet wide, costing from 2½ to 3 millions of dollars each, and have voted the construction of a dry dock to cost $3,000,000. A contract has been made within the

year with the Hamburg-American Line for the inauguration of a high class passenger service with large ships of the "Amerika" class, 22,622 gross tonnage, and efforts are being made looking to the establishment of regular services to the Gulf of Mexico and the West Indies. The activity of the port of Boston and the support rendered by its State may well serve as object lessons to the port of Philadelphia and the State of Pennsylvania.

Transportation in all its aspects is an exceedingly complex subject, involving not only a wide range of technical engineering, but also intricate problems of economics and finance. But to the engineer, in the first place, is due the credit for the wonderful achievements that have been attained. Overcoming all physical barriers he has linked together by sea and land the remotest corners of the earth, and has placed within reach of all the products of the world. Unfortunately, credit does not always fall where credit is due, and although the human race owes a heavy debt to the engineer for its material welfare and prosperity, the financiers and promoters are usually preferred creditors.

PAPER No. 1126

THE PANAMA CANAL AS IT RELATES TO THE TREATIES

BY REAR ADMIRAL C. M. CHESTER (retired).

Read April 5, 1913

The most important question before the American people today is the Panama Canal in its relation to the foreign policy of the United States. We have, by the action of our Government, under the Act of Congress approved August 24th, 1912, in exempting our coasting trade from canal tolls, raised an issue of honor with the nation with which we are most closely connected by ties of interests and race. Honor should come before interests, and the subject requires the most careful treatment before the people commit themselves to a policy, which is not only opposed by England, but by all other nations as well, and which, if persisted in, will surely lower the moral standing of our country in the eyes of the world.

FOUNDATION OF THE TREATIES

It should be remembered that, at the time of the execution of the Clayton-Bulwer Treaty, England claimed sovereignty over a good part of Central America, including the Mosquito Coast, British Honduras and the Bay Islands. The government of the United States, says a good authority, alarmed at the preponderance of British influence in Central America, cast about for a means of counteracting it.

To oust England from her strong position by force was felt to be too grave an undertaking, even were the United States disposed to attempt it. But the American statesmen of the day were, as a rule, only intent in securing a free transit across the isthmus not under the exclusive control of any European nation. They resolved therefore upon a peaceful and conciliatory policy; if England could not be got rid of, she might consent to act in conjunction

with the United States in guaranteeing the proposed isthmus transit.

It was expected at first that the isthmian canal would be constructed across Nicaragua; and the harbor of Greytown, its Atlantic terminus, was included in the claimed possessions of England.

She, then, at our instigation, entered into an agreement with the United States, known as the Clayton-Bulwer Treaty of 1850, and renounced her dominion over Greytown, in order that the canal might be built in accordance with the treaty, and during the lifetime of that document it was used as an argument to prevent Great Britain from extending her possessions in Central America, just as it was used in 1895 with regard to Venezuela.

By this convention the United States was prevented from constructing the Panama Canal without the consent of England, as per Article I of the treaty, which reads as follows: "The Governments of the United States and Great Britain hereby declare that neither the one or the other will ever obtain or maintain for itself any exclusive control over the ship canal." In order to revoke this agreement, the United States was, later, forced to engage in another convention with England, that resulted in bringing into being the Hay-Pauncefote Treaty, which was promulgated February 22, 1902. As Secretary Hay expressed it, this treaty was exchanged "as a consideration for getting rid of the Clayton-Bulwer Treaty."

Intention of the Negotiators

Senator Root and some of the leading members of the United States Senate take the ground that under the Hay-Pauncefote Treaty the United States agreed to treat the vessels of all nations, including our own vessels, on equal terms in the matter of canal tolls, but some of the public press have taken issue with this view of the case, and contend that there is some ground for asking, whether, in framing the Hay-Pauncefote Treaty, the United States deliberately intended to waive in this wholesale fashion her authority to administer the canal for her own necessary protection with due regards to the just rights of the rest of the world. Of course, there could be no argument on this general proposition, if we agreed on what were the just rights of the rest of the world.

This we must judge from the intentions of those who were responsible for making the treaty.

The intent of a law is the spirit in which it was established; and could there be any one in the country today, save the President of the United States at the time the treaty was made, who is so competent to define this characteristic of the treaty, as the preeminently able jurist, Senator Root, who as Secretary of War when the same was negotiated, was in charge of the colonial affairs of the Government, of which canal matters formed a part, and must have been in close touch and close accord with the great statesman, Mr. John Hay, Secretary of State, who signed it for the Government? But aside from Senator Root's official authority regarding the meaning of the treaty, I should like to present some facts as they appear to me.

There are three factors in the problem, which seem to point to the conclusion that the United States did intend to treat the vessels of all nations, including her own vessels, on equal terms in the matter of canal tolls.

Factor No. 1.—A part of Article VIII of the Clayton-Bulwer Treaty reads as follows: "The same canal or railways being open to the citizens and subjects of the United States and Great Britain on equal terms, shall be open on like terms to the citizens and subjects of every other state which is willing to grant thereto such protection as the United States and Great Britain are willing to afford."

Factor No. II.—By Article III of the Hay-Pauncefote Treaty, which replaces the former treaty, the United States again agrees to stand by the terms for equality of canal tolls in these words: "The canal shall be free and open to the vessels of commerce and of war of all nations observing these rules, on terms of entire equality, so that there shall be no discrimination against any such nation, or its citizens or subjects, in respect of the conditions or charges of traffic, or otherwise. Such conditions and charges of traffic shall be just and equitable."

It is clear from this that the principle of neutrality and equality of interests were uppermost in the minds of the negotiators when the Hay-Pauncefote Treaty was signed.

Factor No. III.—But again by Article XVIII of the Convention between the United States and the Republic of Panama, of February 26, 1904, the United States adopts the same fundamental

provision in these words: "The canal, when constructed, and the extrance thereto, shall be neutral in perpetuity, and shall be open upon the terms provided for by Section I of Article III of, and in conformity with all the stipulations of, the treaty entered into by the Governments of the United States and Great Britain on November 18, 1901."

Is it possible for the able statesmen, who were responsible for the good faith of the Government of the United States, in undertaking a solemn obligation to have held a mental reservation that the word "all" in a treaty should not include the United States? I for one will not believe it.

Discrimination of the Treaty

But it is contended by some newspaper writers that the exemption of American coastwise vessels, engaged in the transportation of American merchandise from one recognized United States port to another United States port, is not a discrimination against foreign nations, because such nations are debarred from engaging in this traffic by our local laws, and they cannot be affected one way or another by the treaty. Let us stop for a moment and consider a case in point. Suppose that two vessels, one an American ship and the other British, load cargo, the former at Belfast, Me., and the other at St. Andrews', New Brunswick, ports near together on opposite sides of the St. Croix River, the boundary line between Canada and the United States. The American vessel proceeds to Port Townsend, Washington, via the Panama Canal and the British vessel by the same route to Victoria in British Columbia, just across the Straits of Fucca, from Port Townsend. The American vessel is given free passage through the canal, while the British ship is charged at the rate of from 75 cents to $1.25 per ton for the cargo she has on board. Are these vessels on terms of "entire equality" as is required to be by the treaty? Is not this a discrimination against the British vessel? Many other cases of seeming flagrant injustice might be cited, but I think this is enough to show that England has "probable cause," at least, to make formal protest against the action of the American Government regarding the Hay-Pauncefote Treaty.

Arbitration

But let us suppose for a moment that the words "All Nations" in the Hay-Pauncefote Treaty are susceptible of a construction that excludes the United States from the combination, the case then would seem to come under Article I of the Arbitration Convention between the United States and Great Britain, of April 4, 1908, which reads as follows: "Differences which may arise of a legal nature or relating to the interpretation of treaties existing between the two contracting parties and which it may not be possible to settle by diplomacy, shall be referred to the Permanent Court of Arbitration established at The Hague by the Convention of the 29th of July, 1899."

Abrogation

Mr. Hannis-Taylor, Ex-Minister to Spain, claims that the "radical changes in subsequent conditions wrought by the transfer of sovereignty over the canal zone to the United States, rendered the Hay-Pauncefote Treaty 'voidable,' and subject to modification or abrogation, no matter what its original meaning might have been," and owing to the illusion that this theory is correct, many people are in favor of abrogating the treaty. Here while the fact that "a contract ceases to be binding as soon as anything which formed an implied condition of its obligatory force at the time of its conclusion is essentially altered" is unquestionable, the premises regarding the conditions in this case are not well taken. In the first place, Article IV of the Hay-Pauncefote Treaty prescribes this contention altogether in the following words: "It is agreed that no change of sovereignty or of the international relations of the country or countries traversed by the aforementioned canal shall affect the general principle of neutrality or the obligation of the High Contracting Parties under the present Treaty."

But there is still another obstacle to even the consideration of such a contention as this, in my opinion, namely, the Convention between the United States and the Republic of Panama. This only "grants to the United States in perpetuity the use, occupation and control of land and land under water for the construction, maintenance, operation, sanitation and protection of said canal * * * and all the rights, power and authority * * * which the United States would possess and exercise, if it were the sovereign

of the territory within which the said land and waters are located, to the entire exclusion of the exercise by the Republic of Panama of any such sovereign rights, power or authority." From this it would appear that this is not a grant of full sovereign rights to the United States, but rights as "if it were the sovereign of the territory" to perform specific acts that are well defined, in chosen words. Under this treaty there can be but little question that if for any reason the United States should fail to complete the canal or that Article XVIII of the treaty, as interpreted, not by the United States, but by some form of arbitration, the Republic of Panama would claim her sovereignty to the canal zone.

No, let us arbitrate the Hay-Pauncefote Treaty if we must, but, preferably, let us do what England did for us at one time when the United States protested against unfair treatment in the matter of Canadian Canal Tolls. She caused the orders of the Canadian Government to be revoked, and acknowledged that a mistake had been made. It is better to be right than to have the Panama Canal.

Monroe Doctrine

There is still another factor in the foreign policy of the United States, that is intimately connected with the canal problem. This is the Monroe Doctrine. And in fact this doctrine may be said to be the genesis of all the negotiations relating to the Panama Canal, which have taken place up to the present time; and yet this "Ark of the Covenant" has no standing whatever in international law. Furthermore, it has had so many different interpretations as to cause it to be little understood by the American people.

The original doctrine enunciated by President Monroe regarding our foreign relations insofar as the purpose originally intended is concerned is as obsolete today as was the Clayton-Bulwer Treaty, when it was amended, and it no more fits the present conditions than that did. It was designed originally in the interests of both the United States and Great Britain, which was, in 1823, the only constitutional monarchy in Europe, to guard against the forcible interference of the "holy alliance" between Spain and South America, but now that practically every country of the world is on a constitutional basis, several of them being indeed republican in form of government, there is no need to protect our neighboring republics from European powers, only insofar as it affects our vital

interests, and whether it does so or not can only be determined when the issue arises. As far as the basic principle of the Monroe Doctrine is concerned—the right of self defense—it is axiomatic, and does not require argument. When our interests are threatened, an announcement, such as was recently made in a Congressional resolution presented by Senator Lodge on the subject of Mexico, will answer the purpose.

President Monroe in his message to Congress December 2, 1823, laid down for a basis of our foreign policy this: "It is impossible that the allied powers should extend their political system to any portion of either continent (North or South America) without endangering our peace or happiness, nor can any one believe that our southern brethren, if left to themselves, would adopt it of their own accord. * * * We owe it, therefore, to candor and to the amicable relations existing between the United States and those Powers to declare that we should consider any attempt on their part to extend their system to *any portion of this hemisphere* as dangerous to our peace and safety." This announcement had two distinct purposes in view; first to guard the safety of the United States, and second to apply the doctrine to the whole of South America. Of course, the essence of the doctrine is the defense of the United States, but so late as July, 1895, Mr. Olney, then Secretary of State, defined its territorial requirements as "that no European Power or combination of European Powers should forcibly deprive an American State of the right and power of self government and of shaping for itself its own political fortunes and destinies, but it was futile (he said) to lay down such a rule unless its observance can be enforced. It was manifest that the United States was the only power on this hemisphere capable of enforcing it."

Proposed Changes in the Monroe Doctrine

The South American Republics were then in their infancy and were struggling against great odds for democratic government, and "the United States proclaimed herself the protector of the western world in which she was by far the stronger power" as Secretary of State Bayard expressed the situation, as a matter of necessity under the conditions then existing. The question now is would a forcible attempt by a European Power to acquire territory in

Argentina, at the extreme end of South America, which was then the principle objective threatened, be a menace to interests located so far away as those of the United States: It would seem that now the continent is practically cut in twain by the Panama Canal, and the trade route via the Straits of Magellan is neutralized, the forcible seizure of Staten Island at the extreme end of the continent let us say could have no material effect on the vital interests of the United States, such as it would require force to protect. There is a growing disposition among well informed Americans, to limit the territorial extent to which the Monroe Doctrine should be applied, to the states in South America, that lie to the north of the Amazon River, but here we are met with difficulties in my opinion surpassing those from which we should attempt to escape by such limitation. By holding a protectorate in this restricted field we throw out of consideration all the states to the south of this line of demarkation, at once causing jealousies among the larger and more important of the South American Republics, making them enemies of our defensive policy as selfish in its nature, and probably adding their moral support to our many antagonists in Europe.

No, it were better in my opinion, to maintain the original jurisdiction of the Monroe Doctrine, but to recognize the fact that many of the 20 South American Republics are no longer the weaklings they were when the policy was formulated, unable to defend themselves, but are strong enough to share in the common defense of the continent.

Leading statesmen of Brazil and other South American Republics have declared that the Monroe Doctrine is discredited in the republics for whose benefit it was devised, not because they do not appreciate the good intentions of the United States, but they deny the right of this nation to appoint itself a guardian over their welfare. A doctrine founded upon the principles of James Monroe, but giving the right of a protectorate to the powers in general and not to any country in particular, would be the ideal doctrine, in the belief of the people of Latin America.

The Monroe Monument

On the 15th day of November, 1894, the fifth year of the foundation of the Republic of Brazil, in the presence of the representatives of the principal American Republics, including the United

States, was laid in the city of Rio de Janeiro, the corner stone of a monument to American solidarity. Under this stone this official record lies: "The monument which will be erected on the spot in which this stone is laid, and which will symbolize the political union of the different nations of the continent of Columbus, will be surmounted by the figure of James Monroe, author of the celebrated doctrine known by his name, which teaches that the nations of the new continent should unite for the purpose of preventing any undue interference of the nations of Europe in the internal affairs of America. Around the principal figure will be grouped the great national liberators of America—Washington, Jefferson, Juarez, Toussaint L'Ouverture, Bolivar, Jose Bonifacio and Benjamin Constant."

I would give you this incident and picture to study in contrast to another view, depicting the scowling faces of many South Americans, from whom we are just now seeking commercial advantages, who spurn the foreign policy of the United States as it now stands, shun its commercial policy and belittle its domestic policy.

An Entente

We cannot, however, with propriety, form an "alliance," for that word has been tabooed by an unwritten law of the land, but we can engage in an "entente," as foreigners will call it, with the Republics of South America that will give them a share in the responsibility of maintaining a policy which looks to the general good of all parties concerned. Let us form, then, not an alliance, but a concert of action after the principles of the Monroe Doctrine, which will show that all the states at interest hold the same opinion regarding this doctrine, and the moral effect of such an "entente" will be sufficient to stay the hand of any European nation which may seek political annexation of American territory.

It has been well said that the Monroe Doctrine is as strong as the Navy of the United States and no stronger. It behooves the people of the United States, therefore, to avoid creating enemies who might be tempted in order to protect their own welfare, to form a combination against this country, and bring to bear a maritime force several times as large as what we possess, and particularly so if we continue to limit the construction of vessels for the fleet, in accordance with the policy that has been recently in-

augurated. The formation of an "entente" such as I have outlined would in no way lessen the importance of the upbuilding of the Navy, however, for whatever association is formed of the 21 American Republics, the responsibilities of the United States will not be lessened thereby.

I recall a statement made to me a few years ago by that grand American, the late Dr. Edward Everett Hale, in which he said that a Boston Society, to which he belonged, had pronounced the visit of Secretary of State Elihu Root to South America in 1906 as the most important event of the twentieth century, up to that date, as it had brought the people of North and South America closer together than they had ever been before.

Hon. John Barrett, Director General of the Pan-American Union, which Senator Root was largely instrumental in bringing into being, sends out a New Year's Greeting to the American people in these words: "Let the United States take advantage of the opening of the Panama Canal, to signalize formally, as it were, the beginning of a new Pan-American era in which the Monroe Doctrine, which represents the dictum of one government in the family of nations, shall evolve into a greater Pan-American doctrine, which shall represent the mutual interests and protection of all."

I say amen to this.

It is better to make friends than to build guns.

ABSTRACT OF MINUTES OF THE BOARD OF GOVERNORS.

REGULAR MEETING OF THE BOARD OF DIRECTORS, APRIL 17, 1913.

The meeting was called to order by President Taylor at 8:15 P. M., with Vice-Presidents Plack, Mebus and Swaab, Directors Develin, Gilpin, Vogleson, Berry, Haldeman, Furber, Gibson, Hibbs and the Secretary in attendance.

The minutes of the Regular Meeting of March 13, were read and approved, and the minutes of the Special Meeting held March 17 were also read and approved.

The Secretary's report was read, and the following action taken with reference thereto: The resignation of Mr. H. B. Bryans was accepted as of July 1, 1913, and his dues for the remainder of the year charged off; the resignation of Mr. Michael Monaghan was accepted as of December 31, 1912, and his dues for the year 1913 charged off; the resignation of Mr. Fred. G. Thorn, Jr., was accepted as of December 31, 1912, and his dues for the year 1913 charged off; and the resignation of Mr. Howard B. Green was accepted and his unpaid dues charged off.

The Secretary was instructed to communicate with the American Society of Marine Draftsmen, Philadelphia Chapter, and advise them that the Board finds that it cannot extend the courtesies of their meetings to them, as it would conflict with the By-Laws.

The Treasurer's report was presented and approved.

The Treasurer was instructed to send a statement of Mr. H. R. Wilkinson's delinquent account, amounting to $70.00, and advise him that if this amount were paid, his resignation would be accepted.

The House Committee's report was read and approved.

The Membership Committee's report was presented and Messrs. Eli T. Conner, Carleton E. Davis and John Mellor were elected to Active Membership, and Messrs. A. C. Fisler and Karl Nibecker were transferred from Junior to Active Membership.

The report of the Meetings Committee was read and approved.

The reports of the Publication-Advertising and Library Committees were read and approved.

The Library Committee was instructed to send a copy of the proposed list of books for the library to each member of the Board of Directors, asking them to advise the Committee as to additions or alterations to this list.

The report of the Committee on Public Relations was read and approved.

The Business Manager's report was read and approved.

The proposed revision of the By-Laws as compiled by the Committee on Revision on By-Laws was presented to the Board and certain changes ordered to be made, and this revised copy ordered to be presented at the Regular Meeting of the Club on Saturday, April 19th.

The Secretary was instructed to communicate with the Engineers' Club of oston relative to exchange of privileges.

Mr. Mebus informed the Board that the amendment to the Charter had been ranted by the Court of Common Pleas, No. 4, on March 31, 1913.

Mr. Mebus was appointed a delegate to represent the Engineers' Club at the Annual Meeting of the Board of Trustees of State College on Tuesday, June 10, 1913.

Messrs. Plack and Furber were appointed a Committee to represent the Club in connection with the Fire Prevention investigation being held by the City.

Messrs. Haldeman and Furber were appointed delegates to represent the Club at the Annual Conference on City Planning, and the Secretary was notified to communicate with Mr. George F. Swain, President of the American Society of Civil Engineers, to that effect.

REGULAR MEETING OF THE BOARD OF DIRECTORS MAY 17, 1913.

The meeting was called to order at 8:05 P. M. with Vice President Mebus in the chair and Vice-Presidents Plack and Swasb, Directors Hess, Gilpin, Vogelson, Berry, Yarnall, Gibson, Hibbs, Snook, and the Treasurer in attendance. The minutes of the meeting of April 17th were read and approved.

The Treasurer reported a net gain to May 1st of $1,790.19 as compared with $136.32 of the previous year.

The House Committee's report was presented and approved and appropriation of $29.83 was made to cover the deficit incurred by the Annual Reception.

The Membership Committee's report was presented and approved, and Messrs. F. Van Buren Connell and Richard B. Ferris were elected to Junior membership and E. B. Callow was transferred from Junior to Associate membership.

The Meetings Committee announced that Professor Pence would be unable to deliver his lecture on Saturday evening, May 17th, and that they had secured Mr. J. S. Gibson for that date, and that Mr. D. Robert Yarnall would present the final paper of the season.

The Library's Committee's report was presented and approved.

The Business Manager's report was presented and referred to the Finance Committee, with instructions that they consider it and report to the board.

The Publicity Committee was instructed to issue notices to the members of all meetings to be held at the Club House; and also to report to the Board of Directors relative to the publicity that the Club receives.

The House Committee was asked to report and suggest the best ways and means of bringing to the attention of the membership, notices of meetings to be held at the Club House.

The House Committee and Business Manager were instructed to make a study for the purpose of increasing the patronage in the restaurant, and suggestion was made to this Committee to prepare a scheme whereby a reduction be made for a certain number of meals consumed within a certain time.

The following were appointed to compose the Committee on Nominations for the coming year: H. E. Ehlers, J. C. Wagner, F. H. Stier, Carl Hering, E. M. Nichols, Thomas C. McBride, and George T. Gwilliam.

ABSTRACT OF MINUTES OF THE CLUB

BUSINESS MEETING, MARCH 15, 1913.

The meeting was called to order at 8:30 P. M. by President Taylor, with 117 members and visitors in attendance. The minutes of the Regular Meeting of March 1, were approved as printed in abstract.

The report of the Committee to prepare a memoriam on the death of John Fritz, Honorary Member, was presented by Mr J. Chester Wilson, and was unanimously adopted.

The President announced the death on March 11, 1913, of Frank Burns, Active Member, elected to membership October 17, 1908; and that the Board of Directore at its meeting on March 13, had instructed the Publication Committee to prepare a memoriam on the death of Mr. Burns, to be incorporated in the Proceedings.

The Secretary reported the election of the following members at the meeting of the Board of Directors on March 13, 1913: Active—C. Burke Filbert, Edward C. Fish, William C. Greany, Donald B. Heilman, John H. Neeson, Joseph C. Rock; Associate—Frank B. Johnston, Jacob T. Swartz; Junior—Howard H. Demmert, William N. Edwards, Erle C. Herman, Charles C. Jones, Charles L. Downs, Carl A. Woerwag.

Mr. Hermann V. Schreiber, of Sellers and Rippey, Consulting Engineers, presented the paper of the evening, entitled, "The Design and Construction of the Hydro-Electric Plant at Estacada, Oregon," which was discussed by Messrs. C. P. Birkinbine, Harrison Souder, G. L. Watters, Emile G. Perrot, L. W. Birkinbine, and others.

A unanimous vote of thanks was extended Mr. Schreiber for his admirable paper.

REGULAR MEETING, APRIL 5, 1913.

The meeting was called to order at 8:30 P. M. by Vice-President Mebus, with 132 members and visitors in attendance. The minutes of the Regular Meeting of March 16, 1913, were approved as printed in abstract.

The paper of the evening, entitled "The Panama Canal as it Relates to the Treaties" was presented by Rear Admiral C. M. Chester, U. S. N., retired, and discussed by Messrs. Wm. Easby, Jr., Major Gillette, H. Goodwin, Jr., Thomas M. Chance, John C. Parker, W. Ballinger, O. C. Schmidt, John C. Trautwine, Jr., and P. A. Maignen.

A vote of thanks was extended to Admiral Chester for the presentation of his paper.

BUSINESS MEETING, APRIL 19, 1913.

The meeting was called to order at 8:35 P. M. by President Taylor, with 107 members and visitors in attendance.

The minutes of the Regular Meeting of April 5, 1913, were approved as printed in abstract.

It was announced that in accordance with the resolution of the Club passed February 22, 1913, amendments to the Charter had been granted. These amendments eliminate the inconsistencies in the old Charter.

It was announced that in order that the past actions of the Club and the Board of Directors may be legalized, it will be necessary for the Club at the next meeting to formally ratify these actions.

The proposed amendments to the By-Laws were introduced and laid over for discussion at the next meeting.

The paper of the evening, entitled, "The High Pressure Fire Service," was presented by Mr. John E. Codman and discussed by Messrs. John C. Trautwine, Jr., C. G. Darragh, H. G. Morris, E. M. Nichols, S. M. Swaab. Dr. H. M. Chance and Thomas M. Chance described a new type pump adaptable for high pressure service.

BUSINESS MEETING, MAY 3, 1913.

The meeting was called to order at 8:40 P. M. by President Taylor with 51 members and visitors in attendance.

The minutes of the Business Meeting of April 19, 1913, were amended to read as follows:

"Abstract of minutes of the Business Meeting of the Club held Saturday evening, April 19, 1913:

"The meeting was called to order at 8:35 P. M. by President Taylor with 107 members and visitors in attendance.

"The minutes of the Regular Meeting of April 5, 1913, were approved as printed in abstract.

"It was announced that in accordance with the resolution of the Club passed February 22, 1913, amendments to the Charter had been granted. These amendments eliminate the inconsistencies in the old Charter.

"It was announced that in order that the past actions of the Club and the Board of Directors may be legalized, it would be necessary for the Club at the next meeting to formally ratify these actions.

"It was announced that at the Regular Meeting of the Board of Directors held April 17, 1913, the following were elected to Active Membership: Eli T. Conner, Carleton E. Davis and John Mellor.

"The proposed amendments to the By-Laws were introduced and laid over for discussion at the meeting to be held on May 17, 1913.

"The paper of the evening, entitled 'The High Pressure Fire Service,' was presented by Mr. John E. Codman and discussed by Messrs. John C. Trautwine, Jr., C. G. Darragh, H. G. Morris, E. M. Nichols, S. M. Swaab. Dr. H. M. Chance and Thomas M. Chance described a new type pump adaptable for high pressure service.

"The meeting adjourned at 11:10 P. M."

The following motion was presented by Mr. S. M. Swaab and unanimously adopted:

"Resolved, that all past actions of the Club and of the Board of Directors be and the same are herewith ratified."

The paper of the evening, entitled, "Some Aspects of the Subject of Transportation," was presented by Lt. Col. J. E. Kuhn, U. S. A., Corps of Engineers.

A unanimous vote of thanks was extended Col. Kuhn for the presentation of his valuable paper.

BUSINESS MEETING, MAY 7, 1913.

The meeting was called to order by Vice President Plack at 8:30 P. M., with 63 members and visitors in attendance.

The minutes of meeting held May 3, 1913, were approved as printed in abstract.

The Secretary announced that the Board of Directors, at their meeting of May 15th, had elected to Junior Membership F. Van Buren Connell and Richard B. Ferris.

The Committee on Nominations for the coming year, as elected by the Board of Directors, was announced, as follows: H. E. Ehlers, Chairman; Joseph C. Wagner, F. H. Stier, Carl Hering, E. M. Nichols, Thomas McBride and George T. Gwilliam. This list was laid over until the meeting of June 7th for alteration or acceptance by the Club.

The amendments to the By-Laws were discussed, amended, and ordered sent to the members for ballot.

The paper of the evening, entitled, "Suction Gas Producer Pumping Engine vs. Compound Condensing Corliss Crank and Fly Wheel Pumping Engine, Giving Cost of Operation and Fixed Charges Based upon Five Years' Operating Experience," was presented by Mr. J. E. Gibson and discussed by Messrs. Ledoux, Fernald, McBride, Dallett, Chance, A. C. Wood, Wm. T. Price and Gibson.

SOME INTERESTING FACTS ABOUT PHILADELPHIA

Population (census, 1910) 1,549,008.
Area, 129 square miles.
Lat. of City Hall Tower, 39° 57′ 09.768″
Long. " " " 75° 9′ 47.92″

Normal Mean Temperatures

Jan.	*Feb.*	*March*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Annual*
32.4	33.1	40.5	51.5	62.6	71.6	76.4	74.4	68.1	56.7	45.0	35.4	54.

Normal Maximum Temperatures

39.4	40.3	48.3	55.9	66.3	74.3	78.4	82.2	76.3	64.6	52.4	42.3

Normal Minimum Temperatures

25.7	25.9	32.9	39.5	49.5	58.1	63.0	66.5	60.4	49.0	38.5	29.1

Normal Rainfall

3.26	3.34	3.35	2.99	3.27	3.32	4.08	4.71	3.36	3.01	3.12	3.06	41.51

Highest Temperatures on Record

72	75	86	93	96	98	103	101	97	88	77	68

↓

July 2, 1901

Lowest Temperatures n Record

—5	—6	5	18	34	46	54	51	40	31	8	—5

Miles of Streets

Granolithic Block	352.99
Asphalt (sheet)	472.35
Asphalt (block)	7.49
Vitrified brick	163.63
Cobble	14.02
Rubble	6.69
Slag block	8.13
Wood block	4.06
Cement and Granolithic	11.03
Bituminous macadam	29.01
Waterbound macadam	261.31
Total paved streets	1330.71
Dirt roads	180.00

MILES OF SEWERS

Branch sewers	891.16
Main sewers	190.072
Private sewers	167.096
Total	1248.328

Course of North Broad Street—N. 9° 31′ 23.70″ E.
Course of South Broad Street—S. 9° 30′ 24.18″ W.
Course of East Market Street—S. 80° 47′ 54.52″ E.
Course of West Market Street—N. 80° 48′ 24.70″ W.
The following standards of measurement are used:
Horizontal—100 feet City standard equal 100.25 feet U. S. Standard.
Vertical—U. S. standard is used.
The City datum is 5.56′ above mean tide Sandy Hook.
Philadelphia owns or controls 5,129 acres of ground for park purposes, and has 1,229 acres plotted on the City Plan, but not yet condemned for park purposes.

1913 9 NOV

COPYRIGHTED, 1913, BY THE ENGINEERS' CLUB OF PHILADELPHIA.

ISSUED

VOL. XXX, No. 4 October, 1913 Whole Number 129

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF

PHILADELPHIA

EDITED BY THE PUBLICATION COMMITTEE

CONTENTS

PAPERS

1128. The High Pressure Fire Service, JOHN E. CODMAN 325
Discussion by JOHN C. TRAUTWINE, JR., C. G. DARRACH, E. M. NICHOLS, HENRY G. MORRIS, W. R. CONARD and S. M. SWAAB.

1129. The Sinking and Lining of Shafts, FRANCIS DONALDSON 341
Discussion by ELI T. CONNER, S. M. SWAAB and H. M. CHANCE.

1130. The Design and Construction of the Hydro-Electric Plant at Estacada, Oregon, HERMANN V. SCHREIBER 359

1131. Suction Gas Producer Pumping Engine vs. Compound Condensing Corliss Crank and Fly Wheel Pumping Engine, Giving Cost of Operation Based upon Five Years' Operating Experience, J. E. GIBSON, S. H. WRIGHT 371
Discussion by J. W. LEDOUX, ROBERT H. FERNALD, H. M. CHANCE, W. T. PRICE and A. C. Wood.

Obituary—W. J. Warner 394
" R. A. Shillingford 394
Papers Scheduled for the Fall Term 395
Additions to the Library 396
Some Local Transportation Statistics 398
Abstract of Minutes of the Club 399
Abstract of Minutes of the Board of Governors 400

PUBLISHED QUARTERLY

THE ENGINEERS' CLUB OF PHILADELPHIA

8 West King Street, Lancaster, Pa. and 1317 Spruce Street, Philadelphia, Pa.

SUBSCRIPTION PRICE $2.00 PER VOLUME

JOS. S. KEEN, Jr., Pres. and Gen. Mgr. — J. W. LEDOUX, Chief Engineer
GEO. M. BUNTING, Vice-Pres. and Treas. — JAS. H. DAWES, Supt. of Construction
H. BAYARD HODGE, Sec'y and Asst. Treas. — HAROLD P. KEEN, Supt. of Operating Dept.
W. H. ROTH, Asst. Sec'y — H. S. WILLIAMS, Mgr. Real Estate Dept.
HANNIS, WILLIAMS & BUNTING, Solicitors

THE AMERICAN
Pipe and Construction Company

ENGINEERS and CONTRACTORS
FOR WATER WORKS

112 NORTH BROAD STREET — PHILADELPHIA, PA.

Manufacturers of Wrought Iron Pipe
Lined with Pure Cement

Made with Bell and Spigo Rings or Lead Joins

BLACK DIAMOND FILE WORKS

Established 1863

Twelve Medals
Awarded at
International
Expositions

Incorporated 1895

Special Prize
Gold Medal
Atlanta 1895

G. & H. BARNETT CO., Philadelphia, Pa.
OWNED AND OPERATED BY NICHOLSON FILE CO.

Editors of other technical journals are invited to reprint articles from this journal, provided due credit be given the PROCEEDINGS

PROCEEDINGS

OF

THE ENGINEERS' CLUB

OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877. INCORPORATED JUNE 9, 1892.

NOTE—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. XXX OCTOBER, 1913. No. 4

PAPER No. 1128

THE HIGH PRESSURE FIRE SERVICE

BY JOHN E. CODMAN

Read April 19, 1913

I wish to state at this time that the H. P. F. Service System as now constructed is not by any means a *"One Man Affair."*

As far back as 1895, at the suggestion of Mr. Frank M. Riter, Director of the Department of Public Safety, Mr. Thomas M. Thompson, Director of the Department of Public Works, requested Mr. John C. Trautwine, Jr., Chief of the Bureau of Water, to furnish an estimate of the cost of a 10-inch high-pressure pipe line, on Market Street, from the Delaware river to Broad Street, to be supplied by fire-boats lying in the Delaware river.

In furnishing this estimate, Mr. Trautwine remarked upon the inadvisability of depending entirely upon the fire boats, which, when needed, might be in use elsewhere, and recommended the erection of a permanent pumping station, at or near the foot of Market Street.

Mr. Trautwine's service in the employ of the city were terminated before any practical plans were formulated.

That portion of the city between Race Street on the north, Walnut Street on the south, the Delaware river on the east and Broad Street on the west was known as the congested fire district.

Within this area the water supply from the then existing city water main was seriously deficient, both in quantity and pressure, to even meet the ordinary daily demand made upon it by the varied requirements of the district.

The insurance rates were high and a further advance was made by the addition of the "Pink Slip," a charge of 25 cents per $100; a strong protest was made by the merchants and property owners against these conditions, and a vigorous demand was made for better fire protection. Early in 1900, Mr. William C. Haddock, then Director of Public Works under Mayor Ashbridge, instructed me to prepare preliminary plans and an approximate cost of an independent fire protection system for this district, to include station house, engines and pumps, fire mains, fire hydrants, stop valves and all other accessories. This report was to include data, stating the volume of water, size of mains, area to be covered by the system and a general idea of the proposed plan. Upon the submission of this report, Mayor Ashbridge obtained an appropriation from Councils to begin the work. The sum obtained was not sufficient to build station house and put in the engines and pumps, and provide the independent fire mains.

It was decided to lay the fire mains first and utilize the fire boats for pressure, about 180 to 200 pounds, by making a special Siamese connection to the mains at three different places on the Delaware River front.

The size of the fire mains was the next step considered—to deliver the proposed volume of 10,000 gallons of water per minute at Broad and Market Streets. With the location of the station on Delaware Avenue, it was computed that a 20 inch main of nominal diameter from the station on Delaware Avenue or Water Street, connecting with a 16 inch main on Market Street and a 12 inch main on Walnut Street, 12 inch main on Arch Street, 12 inch main on Race Street, all reaching to Broad Street, with 8 inch branch connections on all north and south streets, would meet all requirements.

The assumed pressure of 300 pounds per square inch on the mains at the station was computed to be sufficient to obtain a pressure of 100 pounds at the end of 50 feet of 2½-inch rubber lined hose, with a 1⅛-inch nozzle, at a height of 300 feet or from the top of any building then constructed in the city. This would allow for a loss of head of 70 pounds or about 162 feet at Broad Street.

It is readily understood that these computations are more or less approximate estimates, owing to the uncertain conditions to be met with in laying the pipes in the streets, but it seems to be a very satisfactory one from the fact that other cities have adopted the same maximum pressure.

The question was then raised in regard to the material of which the distributing mains should be constructed. The proposed pressure of 300 pounds and the sudden variations of pressure required a much heavier pipe than had ever before been used in any city water supply.

Steel mains, wrought iron, cast iron, semi-steel, and even copper mains were suggested and considered. The adoption of cast iron with flange joints was finally made. The thickness of the main was computed for 300 pounds with a margin of safety of $7 + \frac{1}{4}$ inch and with 20,000 pounds tensile strength of cast iron. When the fire mains were laid in the street a connection was made on the west side of the City Hall to the 12-inch main from George's Hill, maintaining a constant pressure from that source of about 80 pounds. A stop valve and check valve, which closed when the pressure was raised above the basin pressure, prevented the water getting back into the basin. (Removed after the filtration system was installed.)

This arrangement of fire boat and basin pressure was in use while the plans for a permanent pumping station were being prepared. The power for driving the pumps was a subject of much study and investigation.

A plan was made comprising four steam engines and pump of 15 M. G. capacity each, which with the necessary boilers and smoke stacks required so much space that its location on the river front was almost prohibitory. Attention at this time was drawn to the gasoline or gas engines for power. Very little practical information was obtainable in 1900 about gas engines, and none of over two hundred H. P., and most of them less, were running in this country. In 1902 the Westinghouse Company put upon the market a 3-cylinder 4-Cycle 300 B. H. P. gas engine. I called Director Haddock's attention to this engine as a suitable motive power for the H. P. system. After an investigation of this engine he instructed me to prepare plans and specifications for this gas engine and standard triplex, double acting inside packed single geared plunger-pump made by the Dean Steam Pump Company, Holyoke,

Massachusetts. All the pumping machinery was constructed to meet special specifications in which a considerable improvement over standard practice was contemplated.

Bids for the installation of this plant were asked for and received from a number of parties, the contract being finally awarded to Messrs. M. R. Mucklé & Company, and I have no hesitation in saying that to them and their persistent efforts in the face of many difficulties, without a single precedent to refer to, they made a success of the Race Street station, the first real independent H. P. F. service pumping plant. All this may seem very simple now, it having passed into history, but at that time, thirteen years ago, many new problems were met and the success of the gas engine plant was confined to a few enthusiastic individuals.

I will quote from the "Underwriters Test, April 18th, 1904": "These tests were so successful that the "pink slip" was removed on the same day, with the following remarks by the Philadelphia Underwriters Committee: "We are free to say that after witnessing several tests we believe it (the high pressure system) ought to and will be satisfactory. It will not only be more economical in its workings, but much more speedy in getting into operation than a steam plant, also much easier to control in this connection and therefore preferable."

I also will read the following excerpt from one of our daily papers:

"Pumping Station No. 2 is located at Seventh Street and Lehigh Avenue. This is the finest high pressure fire pumping station in the world, and embraces all the improvements which seven years' experience with the down-town system developed." * * * * * "Philadelphia's high pressure system, and in particular the new pumping station No. 2, have received unqualified praise from visiting officials from other cities, and it was only a few weeks ago that Fire Commissioner Cole, of Boston, visited this plant and after a careful inspection pronounced it the most complete he has yet visited in his tour of investigation preliminary to the installation of the new system in Boston."

The success attending the operation of the Race Street system was followed by an immediate demand for an independent fire protection system in the northeast mill district. The location of this station was a matter of considerable investigation. It was first proposed to obtain a place on the Delaware river front,

but as in case of the Race Street station the sum demanded for a site was exorbitant, and the long distance to pump the water and the large size of the pumping main required to overcome the friction had directed attention to the property owned by the city at Seventh Street and Lehigh Avenue, which was practically in the mill district and was finally accepted.

Some objections were raised to this place that it would necessarily use filtered water, but when it was pointed out that all the water used now in the steam fire engines is filtered, it did not appear so serious, especially as the cost to fill the five million gallon basin with filtered water would be only $20 more than to fill it with unfiltered water.

In 1908, I was appointed by Director Henry Clay to the position of Consulting Engineer, and received instructions from him to prepare the plans and specifications for a new H. P. pumping station to be located at Seventh Street and Lehigh Avenue; the conditions being the construction of a power house, and the installation of gas driven engines and power pumps, the water supply for the pumps to be taken from the remaining section of what was once known as the Fairhill Reservoir.

This work also included the distributing mains in the streets, the proper size of the mains, the area to be protected in the best practical method, the location of the fire hydrants, stop valves, crosses and tees for the future extension of the system, and the computation of quantities of pipe, fittings, valves and fire hydrants for bidders to make estimates upon which to make their bids.

With the limited means at my disposal, the plans and specifications were prepared and submitted for approval about November 1st, 1908. At this time I suggested a change in the building construction which raised the engine room floor about eleven feet above the former level, thus avoiding the annoyance and inconvenience of making repairs to the pumps and suction mains while under pressure, and eliminating an exceedingly bad design of placing the suction and force mains in a trench, as in the Race Street station.

By the approval of this plan a basement was added to the building in which the suction mains, discharge mains, gas mains and water pipes are all exposed to view, and readily accessible, besides removing the necessity of building a stop house and stable, and eliminating the use of several electrically operated valves, improv-

ing the outward appearance of the building, and adding very little, if any, to the cost of the building. As Director Clay wished for a more elaborate building than the plans contemplated, instructions were given to the City Architect to make the proposed changes in the drawings and specifications for the building at once and have them prepared to advertise for bids upon the work soon after the first of January, 1909. The plans for pipe, pipe fittings, pipe laying, repairs to basin, and for the installation of engines and pumps were already completed.

The work was divided into two contracts, Contract No. 1-A and 1-B, and Contract No. 2-A and 2-B. Contract No. 1-A and 1-B comprised the buildings, gas engines and pumps, and all fixtures complete; Contract No. 2-A and 2-B comprised repairs to the reservoir banks, the pipe lines, pipe laying and all fittings complete.

Contract No. 2-B specified two forms of pipe; one for flanged pipe and flanged fittings, and one for Universal pipe with Universal joints and fittings, the Universal pipe joint being one in which the pipes are cast in six (6) foot lengths and connected by a male and female taper iron to iron joint drawn together by four and six bolts secured in a special form of flange.

Bids for installing this work in the Fairhill District were advertised for January 16, 1909, and the contract for the building, engines and pumps; for repairs to the reservoir, and for laying the pipe mains in the street, using the Universal pipe joint, was awarded to the Millard Construction Company, now Keystone State Construction Company, on February 18th. This company has performed all the work in the north-east mill district. The contractors received orders from the Director of the Department of Public Safety to begin work on the contract, April 2, 1909.

Work on the reservoir repairs—fencing, sodding, grading the banks, and building the retaining walls on Seventh Street and south side of the reservoir—was practically completed in July, 1909.

Work of excavating for the pipe in the street was begun in July, 1909, as soon as sufficient 20-inch pipe was received from the foundry to warrant proceeding with the work without being delayed or stopped for non-delivery of pipe and specials. The Central Foundry Company, of Newark, New Jersey, furnished the 8-inch and 12-inch pipe and specials, and the same company at St. Helena,

Maryland, furnished the 16-inch and 20-inch pipe and specials. Later the Wheeling Mold and Foundry Company contracted to furnish 16-inch and 20-inch specials.

One inspector, employed by the Department of Public Safety, was detailed to remain constantly at each foundry, to inspect all pipe and fittings, and test each pipe casting to 800 pounds hydraulic pressure per square inch before shipment, and to certify to the correctness and compliance with the specification of each casting. Special instructions were given these inspectors on this work, and blanks were furnished them to make their reports in full and sign them as correct and in accordance with the specification and mail the report to the consulting engineer.

A daily report was received from each inspector, and placed on record, showing the number of the casting, weight, and tensile strength of the iron from which it was cast. The numbers on the castings are also recorded by the field engineering corps, as well as the location of the piece in the trench.

Steel crosses and tees were cast at the Baldt Steel Company, Wilmington, Delaware, and the machine work was done by the B. F. Shaw Company, of Chester. All these castings were numbered, inspected and tested by an inspector detailed for this work.

The stop valves and fire hydrants for the street pipe lines were made by the A. P. Smith Manufacturing Company, Newark, New Jersey, and were inspected and tested in the presence of a Department Inspector to 800 pounds hydraulic pressure before being shipped.

All the work of laying the pipe in the street was under the direction of duly appointed inspectors of concrete, bricklaying, pipe joints, condition of trench, excavation and computing quantities.

As the work advanced it soon became necessary to find room for the field engineering corps to make the computations required, and to properly record the same, and prepare the plans and data so obtained for permanent records. For this purpose the house, No. 2250 North Howard Street, was rented from month to month as an office, and is so used at this time.

The first test of the Universal pipe of 20-inch diameter was made on August 31st, 1909, on Lehigh Avenue from Fifth to Seventh Street, a distance of 1,025 feet, with perfectly satisfactory results.

On September 23rd, 2,360 feet were put under pressure. All this pipe was subjected to an hydraulic pressure of 410 to 420 pounds per square inch in compliance with the specifications.

Visits were made to the Central Foundry Company's works at Dundalk, Maryland, to witness the moulding, casting and finishing of the 20-inch pipe, also the method of applying the hydrostatic pressure of 800 pounds per square inch to the finished pipe; also to the Central Foundry Company's works at Newark, New Jersey, to inspect the method of casting pipe at that foundry, and on the same date to the works of the A. P. Smith Manufacturing Company, Newark, New Jersey, to witness the test of fire hydrants and 20-inch stop valves.

Also, on October 26th, in company with Mr. S. Scofield, engineer for the firm of S. Schofield and Company, I visited the works of the Westinghouse Machine Company, at East Pittsburgh, Pennsylvania, and witnessed the test of two gas engines erected on the floor of the machine shop, and operated with natural gas against a Prony Brake attachment, the resistance varying from no load, one-quarter load, one-half load, full load, and over load, gas consumption per cubic foot, and B. T. U. required per brake horse power, all of which was satisfactory and in accordance with the specification.

The combined capacity of the two stations is, approximately, 2,910 cubic feet per minute, or about 33,000,000 gallons for twenty-four hours. For this purpose the Delaware Avenue and Race Street station is provided with seven Westinghouse gas engines, driving Dean triplex double acting piston pumps of a capacity of 1,250 gallons per minute each, and two small engines and pumps of 350 gallons per minute. The water is taken through a 36-inch steel suction main from the Delaware river to the pumps and delivered through one steel and cast iron water main into the distribution system. The area covered by this station extends from the Delaware river to Broad Street and from Race Street south to Walnut Street; on Front Street north using the New main to Girard Avenue, out both Girard Avenue and Richmond Street to Norris, Aramingo Avenue to York Street, Thompson Street to Lehigh Avenue. Of course hose can be run from the hydrants on Race Street or Walnut Street a considerable distance north or south of these streets and from Broad Street west.

The Fairhill High Pressure Fire Service Station, located at Seventh Street and Lehigh Avenue, on lot formerly occupied by the Fairhill Reservoir, is provided with 10 Westinghouse gas engines driving Dean triplex double acting piston pumps of a capacity of 12,500 gallons per minute, and one small engine and pump of 350 gallons per minute making a total of 12,850 gallons, or approximately 18,000,000 gallons per 24 hours at a pressure of 300 pounds per square inch. The water for supplying this station is taken from one of the small sections of the reservoir, remaining after the city had disposed of two of the original three (3). The water for supplying the basin, which has a capacity of nearly 5,000,000 gallons, is taken from the water bureau main on Lehigh Avenue through a 14-inch pipe formerly used for conveying water out of the basin on the Seventh Street side. This supply is controlled by a motor-operated valve in a brick stop house and is connected to the switch board in the engine room to open or close it. This supply comes from the Queen Lane distribution. There is also a supply connection to the basin on the Sixth Street side from the Oak Lane Reservoir, both supplies being independent of one another.

In arranging this station all improvements that were suggested in the practical operation of the Delaware Avenue station were adopted. Some improvements are made on the gas engine that facilitate the operation in starting and in running. The water in the basin is ten or twelve feet above the surface of the ground on which the engine house is built. The plan adopted of constructing the engine room floor eleven feet above the ground and using the basement for the suction and delivery mains, gas mains and meters, jacket water supply, steam mains for heating and electrical conduits, proved to be of a very decided advantage. The arrangement for keeping the mains full and under pressure from the basin, avoiding the liability of pumping the water through a defective check valve back into the filtered water system, was made by connecting the discharge main with the suction main. All of these pipes are in duplicate, and are painted a different color, making it very simple to locate water mains, gas mains, injection water, and steam heating main. In the engine room, the engines are arranged five on each side and can be run together or separately. One side can be run independently of the other. All the water used in starting the engines is connected back with the suction mains, so no water

is wasted either in starting or in running. Duplicate discharge mains are carried outside of the building and connected to the mains in the street. Compressed air is used in starting the engines from tanks carrying 200 pounds air pressure. Ignition current is brought in from the outside, and is used, the current being alternate, to drive an alternate current motor which drives a direct current generator from which the ignition is taken to the engine from the switch board. The small engine drives a direct current generator.

There is also a series of storage batteries which can furnish current for 36 hours or more, giving three sources of ignition current. Gas is brought in in two twelve inch mains on each side of the building.

The alternate current motor also drives an air compressor and is capable of driving generator or compressor or both together. The small engine also drives an air compressor independent of the other one, giving two sources of air supply into tanks holding four times the necessary supply to start all the engines.

The area proposed to be protected by this station is bounded by Girard Avenue on the south and Allegheny Avenue on the north and approximately from the Delaware river to Broad Street. The mains are of a nominal diameter of 20″, 16″, 12″, and 8″, the actual diameter being somewhat less.

The contract for the engines, pumps, alternate and direct current motors and air tanks was so far advanced by July 25th, 1911, that the alternate current motors could be started and the air compressors were ready to fill the air tanks. The next day, July 26th, the first one of the engines and pumps was started and run successfully for several hours under a pressure of 300 pounds per square inch.

This was accomplished by closing all the discharge valves and sending the water through the automatic relief valves which were adjusted to a pressure of 300 pounds per square inch. This discharge water was forced into the suction mains through the pipe provided for this purpose; thus all the water used in testing the pumps was forced back into the reservoir to be used over again.

This was an important part in the design of the station, as the water in the reservoir was supplied from the City mains, and could not be unnecessarily wasted. All of the eleven engines are connected in the same way.

On July 27th, three (3) more engines and pumps were started and run for several hours under the pressure of three hundred (300) pounds per square inch.

On July 28th, six (6) more of the engines were started and run under the pressure of three hundred (300) pounds per square inch.

It is a most remarkable fact that these engines and pumps, which had never been turned over before, should without any previous trials so easily and practically perform the full work required by the specifications in the first trial. All mechanics know very well how difficult it is to make any machinery work up to the full computed load at the first trial, particularly when the load is as great as three hundred (300) pounds per square inch, equal to 43,200 pounds, or 21½ tons per square foot of pump surface.

On September 15th, 1911, the twenty-four (24) hour test of one of the pumps was made to fulfill the conditions of the specifications that the pumps should run without interruption under a pressure of three hundred (300) pounds per square inch continuously, and should not in that time develop any defects either in capacity or structural weakness. This was satisfactorily completed on the morning of the 16th, and the pump was stopped, opened, and an examination of the working parts made to ascertain if any defects had developed. Everything thing about the pumps and gas engines was found to be in perfect order, and no indication of any weakness shown.

The method of operating the station is very simple. When an alarm is sounded on the gong in the engine room, indicating a fire in the H. P. fire system district, the engineer starts one engine and brings the pressure up on the main to 100 pounds, and waits for orders from the fire by 'phone. This may either be an order to stop, "not needed," or for more pressure, which is increased at once to 150, 200 or 250 pounds, as called for, and starting one or more engines as the volume may be required, always keeping the pressure constant, as orders over the telephone may be given from the fire. The station thus has nothing to do with the use of the water at the fire, the engineer following implicitly the orders of the chief of the Fire Bureau or his authorized assistant, thus avoiding any conflict of authority as to either volume or pressure.

At Seventh Street and Lehigh Avenue, I instructed the engineers not to raise the pressure over 250 pounds when pumping into the fire mains, as there is a static head between the lowest point in the system and the pump gauge of about 113 feet or nearly 50 pounds per square inch. The relief valves were set to open at this pressure. At the lower or Race Street station instructions were given when the station was first put into service to carry 300 pounds on the pump gauge; as this station is about 100 feet or more below the highest point in the system, and the relief valves were set to open at this pressure.

At the Seventh Street and Lehigh Avenue station there are two steel delivery mains from the engine room to the street main. In each of these mains there is a regulating valve, operated by a current motor controlled from the switch-board in the engine room, making it very easy to regulate the pressure on the whole system. The surplus water or relief from these valves is discharged into the suction mains connecting with the reservoir. No water is wasted from these valves. This arrangement of regulating valves is not on the Race Street station, they being regulated by the motor-operated valves on each engine.

There are at this time about 51 miles of H. P. fire mains from both pumping stations, composed of about 37 miles of Universal pipe and 14 miles of Flange pipe, varying in nominal diameter from 20″, 16″, 12″ and 8″. There are now about 880 fire hydrants in use; all of these hydrants have 8″ valves in the 8″ connections to the supply mains; 1½″ air valves are placed at all summits; 20″, 16″ and 12″ valves are placed in the mains when it is judged they would provide means for making a cut out quickly in case of a break. Provision was made in laying the main at every street intersection for future connections.

It was decided when this Seventh Street station was built to supply it with motor-driven hose- and ladder-trucks and an item for the purchase of the same was made in the appropriations of 1910 and 1911, and as before mentioned the elevation of the engine room floor provided for a garage, and rooms for the chauffeur and hosemen, and provisions being made for gasoline tanks and pumps, water for washing motor trucks and also a motor truck for the line walkers and repair gang.

The total cost of the systems, both Race Street and Seventh and Lehigh Avenue, including fire main, fire hydrants and stop

valves, is not far from two million seven hundred and fifty thousand dollars ($2,750,000). When we consider the amount of property saved and protected by it, this does seem to be a very profitable investment. Cost of running is very small. The bills for gas for the Race Street station have been from $1,500 to $2,200 per year, including all gas used at the station for lighting and other purposes.

DISCUSSION.

MR. JOHN C. TRAUTWINE, JR.—About ten years ago I contributed to the Club Proceedings a paper describing the Philadelphia high-pressure fire system, as then served from the fire boats in the Delaware river. In the same number of the Proceedings appeared a paper by Mr. Codman describing the first high-pressure fire pumping station, designed for the site at the foot of Race Street.

Mr Codman's present paper, describing the new station on Lehigh Avenue, with its pipe system, and the connection of the old and the new systems into what is conceded to be at least one of the largest and finest high-pressure fire systems in the world, happily brings the matter to date, and the Club is to be congratulated upon the reading of such a paper, coming, as it does, from the man who designed and built the entire combined system, and who, therefore, from his intimate acquaintance with it in gross and in detail, is best qualified to describe it.

As the work was not begun until after I had left the Bureau of Water, I have only an academic acquaintance with its technical features; but we have with us this evening Mr. Charles G. Darrach, who has given these matters close professional attention, and who is therefore in position to discuss Mr. Codman's paper from the standpoint of one having authority.

MR. DARRACH.—I would like to ask if Mr. Codman will give us some litttle information about the difficulty of starting and the time required to get up his pressures, with the gas engine. Many of us have had experience with the electric service, with which we can get up the pressure in a very few seconds or half a minute, but I have not had any experience whatever in connection with the gas engine, and I would like to know something about it.

MR. CODMAN.—The pumps are started with compressed air from the air tanks, with no pressure on the mains, and in 40 seconds can be raised to 300 pounds pressure on the pump; but of course not 300 pounds pressure on the main in the street in that length of time, because there are places where there is air in the main, and there is always more or less resiliency in the main, so that at Seventh and Lehigh I suppose it would be five or six minutes before 100 pounds would be obtained in the street.

MR. DARRACH.—Do you use automatic air valves?

MR. CODMAN.—No, we never found them satisfactory. We use an ordinary valve in a brick stop chamber The air valves were placed on all summits.

MR. DARRACH.—The mains are always full of water, are they not?

MR. CODMAN.—Yes. The two suction mains lead through the building into the reservoir, with a full turn at the front of the building, making two double suction mains in the building, with three stop valves, and above these the delivery main is placed, going out the front of the building into the street. The connection is made from the suction to the delivery mains, and the check valve is in this connection. The water from the reservior is always on the system. When the pressure in the main rises, the check valve will close. The danger of a check valve not being always absolutely reliable has been spoken of several times, and if connected to the filtration system, it might send the water back through that pipe into the filtration system, but with this arrangement it cannot get into the filtration mains, and if the valve should trip up, all connections are made so that the water goes back into the basin again.

MR. DARRACH.—Is the distribution all below the reservoir elevation?

MR. CODMAN.—Yes. There is about 10 pounds pressure in Lehigh Avenue, and at Delaware Avenue and Front Street, which is the lowest part of the system, there is about 50 pounds pressure from the basin that is on the mains all the time.

MR. E. M. NICHOLS.—Are all those valves mechanically operated?

MR. CODMAN.—They are operated by hand.

MR. DARRACH.—In regard to air valves, a great many years ago we laid a 30 inch main from what is now the main pumping station from Lardner's Point Reservoir, about four miles of pumping main, following the undulations of the streets, and I was discharged because I laid an undulating pumping main, but we put ordinary hand-operated air valves on the summits. I think that main was laid in 1876, and we never had any trouble during ten years. I tried them ten years afterwards and did not find any air in them; we did not find any accumulation there at all in ten years. Of course the great difficulty is in repairing when you empty your main, then you get your air in and you have to get it out again, and, in fact, during the early history of the City, Germantown and Chestnut Hill were without water one afternoon. They had to open the air valves across from Manayunk and the surveyor came in in a wagon (we did not have the valves then), and there was only six inches of water in the Mount Airy Reservoir, and he said he had opened all the air valves, but upon investigation we found that he had not, and we succeeded in getting the water started; but there was a 20 inch main that was plugged entirely by the air in one summit.

MR. HENRY G. MORRIS.—It is a good many years since I made the acquaintance of Mr. Trautwine, but I do not know anything about this pumping situation, except what I have seen along the streets in laying the mains.

I would like to ask Mr. Codman whether he knows anything about the facing of the flanges on the main down Fourth Street. The ordinary practice in facing flanged pipe is to back face the bosses where the bolts go through. The contractor or whoever made the pipe had ingeniously put a double tool on the facing machine and faced the back of the flange at the same time that he faced the front side; the result was that the fillet was cut down to a sharp line, thus weakening the flange, and some of these days the flanges so weakened will break. I hope Mr. Codman will not be there to see it. I do not know anything about the subject myself, except that it is contrary to established practice.

MR. CONARD.—I do not know of anything that I can add of particular value to this discussion. The paper that has been given us tonight has been very interesting. My experience with high pressure fire service systems in other cities has been along the line of the inspection of the materials at the place of manufacture, largely, though I have of course been interested to observe the various methods worked out. I believe the first high pressure line for fire service put in in this country was in the City of Cleveland, Ohio, and was made up of a short system of ordinary bell and spigot pipe of a heavier class than is used for ordinary pressures; simple connections were made along the water front for attaching to fire boats. Mr. Nichols had something to do with that, and he can probably describe some of its features to you. They are now preparing to install a large pumping plant there and have a regular separate system all through the congested district in Cleveland, and operate along similar lines to the system in use here in Philadelphia. This system, however, will be the same as they have used heretofore; heavy bell and spigot pipe, ordinary bells with a single lead groove and with the ordinary bead. At the present time they are just about starting on the installation of a high pressure system in Boston, Mass., and it is my privilege to look after the special castings and the pipe for this work; they are all bell and spigot pipe with double lead grooves in the bell and double grooves at the spigot end. They have made very exhaustive tests there for the best form of joint, and for the best material to make the joint of. They at first designed their special castings and some of their pipe with lugs, expecting to tie them together with bolts in order to take care of the thrusts. They, however, determined that this was undesirable; it is a question as to how long the bolts will last and perform their function before they will rust out, so that in making the experiments they tried to hit on some plan of making a joint and avoid the use of the lugs. They finally made some tests using various percentages of from two to six per cent. of tin, and by this it was found they could get very good results. The best results were on an average of about four per cent. of tin, but after a number of meltings of lead, the tin evaporated, and they lost the value of the tin, so they finally hit on using a small percentage of antimony—I think about 3.5 per cent.—and I believe they are getting satisfactory results and have eliminated the lugs from special castings, and expect to make the entire system without any lugs at all.

That is about all I can say that would be at all descriptive of other high pressure systems, except possibly in regard to Newark, N. J., where they use bell and spigot pipe for their high pressure system. Therefore, at the present time it seems to be a general practice to use bell and spigot pipe of cast iron, though Baltimore, we understand, has used steel pipe and steel casting; there is quite a big description of it in this week's "Engineering-Contracting."

MR. E. M. NICHOLS.—If it is a matter worthy of pride, I presume that I ought to feel proud of being represented as one of the engineers of the first installation of a high pressure fire system. In the city of Cleveland Ohio, where the first trial of special high pressure service was installed, the pipes ran from the river to the upper part of the town; the hydrants had no main valves; the nozzles for attaching the hose were, however, provided with independent valves; this was in 1892.

Later in the year, the City of Milwaukee started on practically the same plan and I had something to do with the equipping of those lines, but all that was very simple as compared to this.

MR. DARRACH.—I would like to ask whether the lead packing in the joints blows out at all under those heavy pressures, or whether the tendency is for the lead to blow out of the joint? I rather think that is why the tendency had been to avoid the use of lead, and that was my thought when I made my early experiments in the matter. It is our experience that the lead will blow out, sometimes going out half an inch, and with an excessive pressure of 300 pounds, and the excessive pressures of the fire service, the tendency of water hammer would be so great as to be liable to blow those joints out at any time.

MR. CONARD.—The most extensive tests that have been made up to the present time with bell and spigot joints were made in San Francisco for the high pressure fire service that is just about being completed there. They tried all sorts of joints and tested them, and the best form that was devised was, as I mentioned, the type that has been adopted by Boston. Boston has practically a duplicate of the joint used in San Francisco. In the tests that Boston made, the lead would not exactly flow, but would start to flow; the pressure at the back would start plain lead flowing at, I think, about 125 pounds. With the four per cent. of tin added, there would be no perceptible flow up to 300 pounds. From 300 to 400 pounds the lead would flow about 1-16″ or project from the face of the bell about 1-16″ and then remain staionary to 900 pounds, and at 900 pounds the castings burst, so that there is no telling how much further they would go before the lead would actually blow out; but in tests made in San Francisco to the breaking point, they got the pressure up to 2500 pounds, and at 2500 pounds the joint had not parted, although there had been some flow of the lead; just how much, I do not know.

MR. NICHOLS.—The City Engineers of Milwaukee and Cleveland said their highest pressures did not exceed 275 pounds, but they had no trouble at that time with their joints.

MR. SWAAB.—The advantage that I can see in the Universal pipe that Mr. Codman spoke of is, that it does not matter what the nature of the ground is, because you are not depending upon the bolts. I recall a line that was laid into the subway when it was constructed; part of it lay on the roof and part of it in back-filled ground, and it was hard to keep the pipe together, and it seems to me that this pipe could be laid in any old shape and would still hang together.

MR. DARRACH.—Mr. Codman told me some time ago in a conversation I had with him that after the pipe had been drawn together, there was no strain upon the lugs or the bolts at all; that the pipes were held in position with the Universal joints, so that you had an absolutely iron to iron joint.

Of course the whole question comes in as to cost, but it seems to me that, even in the case of the flow, there is always a cause of uncertainty in regard to a fire department line.

PAPER NO. 1129

THE SINKING AND LINING OF SHAFTS

BY FRANCIS DONALDSON

Read March 1, 1913

When mining was begun in America timber was cheap and plentiful, the deposits of virgin coal and ore were widely distributed and could be reached at no great depths, and the development of the rectangular timbered shaft was the natural result. Nowadays shafts are becoming deeper, mining installations more and more

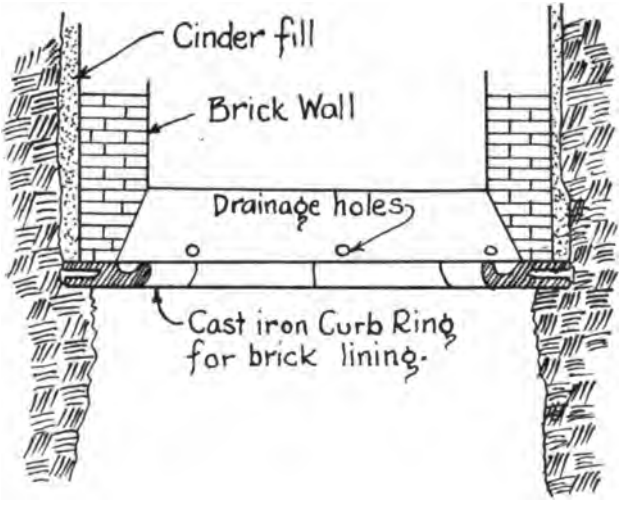


FIG. 1.

expensive and mining men are beginning to think they could possibly get better results by a partial return to European methods, and by the use of permanent linings. European shafts are generally circular, about twenty feet in diameter, and where the rock is moderately dry they are lined with brick excluding the water that may occur in the fissures. As the shafts are sunk, and at intervals of about seventy-five feet, iron curb rings are placed as follows:

A cast iron ring made of sections bolted together with a groove or gutter on the inside (See Fig. 1) is placed in a notch cut in the rock. With this curb as a foundation the brick lining is built up to the ring above. As a rule the brickwork is built from a staging or platform suspended in the shaft in such a way that the sinking

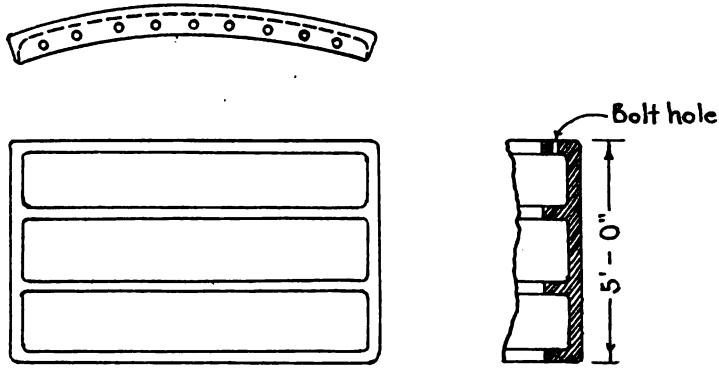


FIG. 2.

bucket can go up and down without interference. The lining is placed rapidly, as many as 3,000 bricks a day being laid by one man. The water that comes in through various seams in the rock is drained through passages in the curb ring to the gutter and conducted thence to a pipe in the shaft running down to the pump.

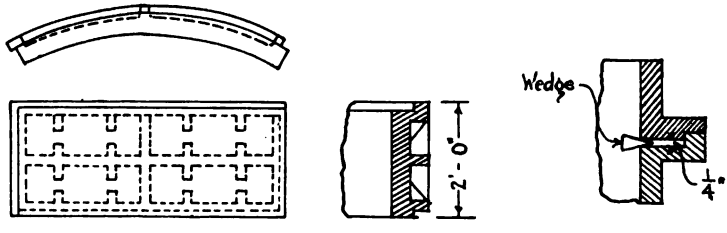


FIG. 3.

The interior of the shaft is thus made absolutely dry and none of the water can fall into the shaft and interfere with the operation of the cages.

Where the rock is very wet the Europeans do not believe in pumping and keeping 3,000 or 4,000 horse power in boilers to run pumps, so they use a shaft lining made of cast iron plates—some-

times as much as 2½″ thick—this is very heavy of course, but effective. There are two types of plates or "tubbing," the German and the English. The sections of German tubbing (Fig. 2) are made with internal flanges and are connected by heavy bolts; the English tubbing sections have external flanges and are so constructed as to lock together without bolts or gaskets (Fig. 3) and are made watertight by wedging. The English sink straight through the wet rock into an impervious stratum and then set a curb ring upon which the regular tubbing is built up. I am going to read an account by an Englishman giving a detailed description of the method of placing this tubbing and also illustrating the great difficulties sometimes encountered in England.

"The shaft was sunk about 9 or 10 feet into the impermeable stratum, of the full diameter of say 23 feet, and then decreased abruptly to the finished size of the shaft, say 20 feet, and the sinking was continued a further distance of 6 or 8 feet. The cradle was then lowered into the pit-bottom, and a temporary wood water-ring was fixed on dowels about 9 or 10 feet above the site selected for the sides of the shaft was then collected in this temporary water-ring and allowed to run off in canvas hoggers or trunks at two or three different positions to the wind-bore of the pumps. As much as 6,000 gallons of water per minute was collected in this manner, above the place where the sinkers were employed preparing the bed for the wedging curb, with the result that in all cases the beds were properly leveled and prepared for the curbs in the most favorable circumstances possible under such conditions.

"The cradle having been fixed in position, the sinkers proceeded to level the surface of the rock-bed with mattocks, and when this was accomplished to the satisfaction of the engineer, a wedging-curb, three segments of which were fitted with valves to pass gas or air accumlating behind the tubbing, was laid on the bare rock, seasoned redwood sheeting ⅜″ thick was placed between all end joints, and the spaces between the back of the curb and the rock were filled with dry wood gluts to bring the inside of the curb up to the finished diameter of the shaft. Afterwards well-seasoned tapered dry-wood wedges were driven into the wood packing between the back of the curb and the strata until the steel chisel-points refused to enter. Then a layer of ⅜″ horizontal sheeting was placed on the top of the wedging-curb, and the 2-foot foundation-course of tubbing was put on, breaking joint with the curb,

⅜″ end and horizontal red-wood sheeting being placed between the joints, and the course was brought up to the correct radius of the shaft by means of wood packing. Next one or two courses of plain tubbing were put on, the fourth course usually containing three or more special segments (technically termed "valve segments"), cast with holes 4 to 6″ in diameter in the center, with the object of permitting the water to pass from the back to the front side of the tubbing, and so to the pumps, when the temporary wood water-ring was removed.

"The next operation was to wedge lightly the vertical joints of the three or four courses of tubbing, and to run the whole up solid with good cement grout. The temporary water-ring was then removed, and additional courses of ordinary tubbing were built on, to a total height of about 60 feet. The joints were now lightly wedged, commencing from the top with the vertical joints, and from the bottom with the horizontal seams, using red-wood wedges. Additional courses of segments of suitable height being used to close up to the wedging-curb above, the vertical and horizontal seams were again twice wedged alternately as before, and the small center holes in each segment were plugged. Finally the large holes in the valve-segments passing the feeders were plugged simultaneously, with long tapered plugs of wood, the excess being sawn off flush with the front side of the orifice, the cast iron caps were bolted on to the flanges, and the shaft was rendered dry if the work had been well carried out."

These two shafts were sunk by John Joseph Prest at Hordeu, through magnesian limestone, in Northeast Durham County.

Six thousand gallons of water per minute were pumped out of one shaft.

The reason I read all that was to show to what trouble and expense they go to in Europe to get a tight shaft. A 2½″ cast iron lining 20 feet in diameter is a very expensive proposition.

As long as we are on this subject of wet shafts, I may say that I wrote Mr. Prest and asked him how he could get men to work in the shaft with 6,000 gallons of water coming in every minute. Somewhere in this article he says that the water as a rule was 3 feet deep. He wrote back to me as follows:

"I am in receipt of your letter dated 17th inst., and in reply thereto I beg to inform you that after a round of holes are fired, the material is loaded up from the pit bottom in the ordinary way,

and when exceptionally large stones are met, the sinkers dip down below the water and collar hold of them, as you suggest.

"It is not customary in this part of the world for sinkers to wear anything except rough flannel trousers and shirt, with a waterproof back-skin, when sinking, and in the case of our shafts the sinkers are wet through practically the whole of their shift except on the back.

"Sumps are made under each set of pumps, and are kept as much as possible in advance of the pit bottom, and holes are drilled systematically round the whole of the shaft bottom to a depth of 6 or 7 feet, as required, and are fired electrically from the surface.

Under ordinary conditions, a new section of wet spear rod can be put on and bolted up in 3 hours; when any additional ground spears were required the time occupied was usually from 9 to 12 hours.

"The maximum boiler horsepower in use at any one time would not exceed 3,000."

The water was handled by the old type Cornish pumps and the method has not been improved.

In 1838, the Murton shafts were sunk and there they handled 9,300 gallons of water from a depth of 450 feet where the impervious rock began. This is a greater quantity than we are able to handle in sinking in this country today with all modern appliances. It is generally known that the Europeans are away ahead of us when it comes to difficult mining propositions.

The Kind Chandron process has been developed to bore a shaft 15 feet in diameter from the top to a depth of 600 or 700 feet, to line it with cast iron tubbing and to seal it to an impervious stratum without a man going down into the shaft. The Europeans have also evolved a sinking drum system similar to our caisson method but on a more extensive scale. They sink a circular masonry caisson for 50 or 60 feet, building into the upper part a cast steel reaction ring, then build up circular cast iron tubbing with an outside diameter slightly smaller than the inside diameter of the caisson. From the bottom to the under side of the reaction ring a heavy cutting edge is provided. Powerful hydraulic jacks are placed between the reaction ring and the top of the tubbing, and the whole thing is jacked down, rings being added and the material being removed with a grab bucket. In that way they have penetrated five or six hundred feet in quicksand without anybody going down into the shaft. In this country when we go down 150 feet without anybody going in the caisson, we think we have done a particularly remarkable piece of engineering.

Brick or cast iron will not wear out; they are safe against fire, and in a long lived mine are cheaper in the end than less permanent linings. On the other hand they call for a circular shaft, and in a shaft with several compartments rectangular construction is much more economical and includes less waste space than any other. In Europe the development has been largely due to the geological conditions. The Europeans have been forced toward their methods by the fact that the coal and the minerals are all deep down; they have had to go down through great depths of marl and limestone. Ninety per cent of the total footage of shafts in this country is in solid rock, and our problem is to meet the European requirements of safety, permanence and the exclusion of water without going to the great expense that they are put to in lining.

In pursuance of this idea a number of mining companies in this country have sunk shafts and lined them with concrete. The United States Coke & Coal Company were the pioneers and they sunk two elliptical shafts in West Virginia about 200 feet deep and lined them with concrete. About three months after the mine started operation there was an explosion which wrecked the mine and killed eight or ten people, but the shafts were not injured in any way, and the operation of the cages was not stopped for an hour. They were able to go right ahead and proceed with their work of rescue and the rehabilitation of the mine itself.

It is only lately that the European requirement for the exclusion of water has been met, and that has been done on the Catskill Aqueduct. The condition has been met by cement grouting. The T. A. Gillespie Company had a contract for the Rondout Siphon, which was a deep circular pressure tunnel under the Rondout Valley. The tunnel was about 5 miles long, and it was expected that they would meet considerable water. They did not, however, except in one shaft which was put down on a fault between limestone and conglomerate; great quantities of water were encountered here. This shaft was sub-let to a Pennsylvania contractor; he struck about 1,500 gallons of water per minute, put in all the pumps he could get and could not do anything with it. The shaft had reached a depth of 350 feet when it stuck. There had been a lot of water coming in on the side of the shaft, (Fig. 4)—a rectangular construction shaft by the way, lined with timber—and when the sinkers struck two or three more fissures in the bottom and got still more water it was the last straw and it broke the back of the pumps.

Mr. John P. Hogan, a Division Engineer of the Board of Water Supply, then suggested that cementation be tried, and it was tried there for the first time in this country. The shaft was full of water, so they put in a platform as low as they could, installed a diamond drill, and drilled six 90-foot holes in the bottom of the shaft. They

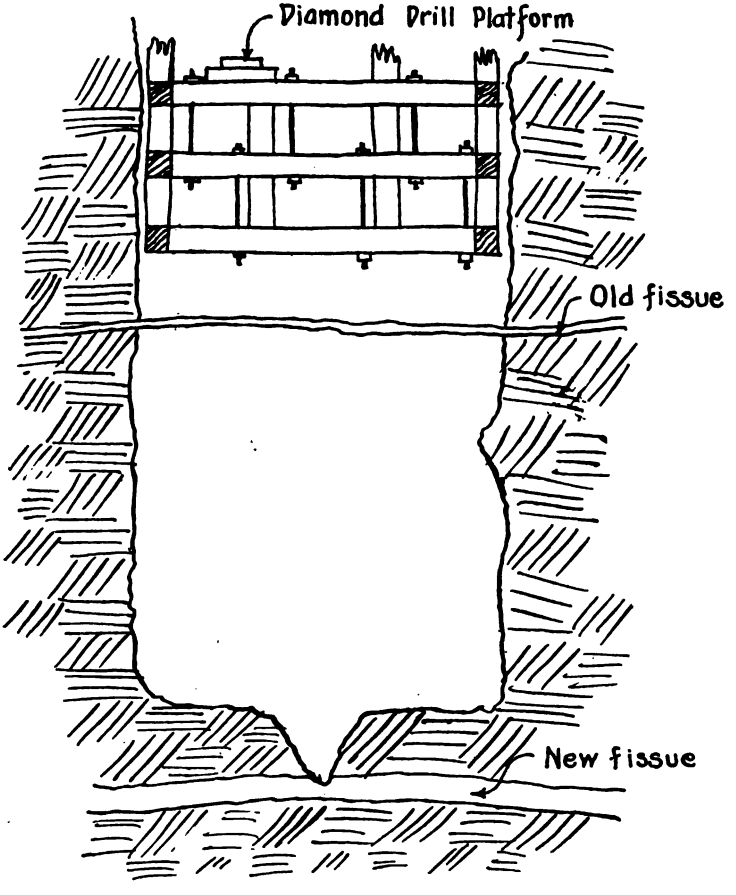


FIG. 4.

pumped them full of cement grout, forcing it through the diamond drill casings. Before they went much further they encountered another leak of about 750 gallons a minute; as they drilled the bottom the water poured in through the machine drill holes they were going to shoot. So they simply plugged up those holes, then

removed the plugs one at a time, drove in pipes connected to a grouting machine, pumped grout into the holes and cut the water off that way. By that means they were able to reduce the flow until they could put in a permanent pump station and handle the water.

The next shaft on the aqueduct where water was encountered was Shaft No. 4, (which I had charge of) in New York City, Borough of the Bronx. We went ahead and made good time until we got to a depth of about 100 feet. We were then drilling into the bottom when we struck a stream of water of about 150 gallons a minute in the first hole we drilled. We plugged that with a hard wood plug and cut the water off, drilled another hole and got the same flow, and so on all around the shaft. We drilled 12 sump holes, all pointing in, and got water in all of them but two. We saw there was no use pumping them and we got ready for grouting. I would like to describe the method by which we got the water choked off.

As soon as each hole cut the water bearing seam we plugged it, as stated above, with a tapered wooden plug. After all the holes in the sump had been drilled and plugged in this way, we made the grout connections one at a time so as to restrict the flow of water into the shaft. Each connection is made with a piece of 2″ or 2½″ iron pipe about three feet long. This is threaded at one end and given a long taper at the other. The tapered portion is made rough on the outside by nicking it with a chisel. A heavy iron "stop-cock" is screwed to the pipe, the tapered end is wrapped in several thicknesses of burlap, the wooden plug is then removed from the drill hole and the tapered pipe driven in, the stop-cock being left open. This is the most exciting and wettest part of the job. After the pipe has been driven in hard the stop cock is closed.

In this case we put connections in all the wet holes before grouting. The grouting machine or tank used on the Aqueduct was the Canniff machine (see Fig. 5) in which the grout is mixed by air. It is built like an air lock with a door on the top through which cement, sand and water are introduced, a 2″ discharge opening in the bottom and air connections top and bottom. The discharge opening is connected to the grout hole by a heavy rubber hose. Another 2″ stop-cock is placed at the outlet of the tank and a 2″ x 1″ tee is placed between the hose and the cock attached to the pipe in the drill hole. Into the side opening of this tee a 1″ stop-cock is screwed.

The machine is taken to the bottom of the shaft, is connected to one of the holes and is also connected to the high pressure air supply. The 2″ stop-cock on the machine is closed and the other is opened. The door in the top is opened, a sack of cement, three or four buckets of water, and, if the cavity to be filled is large, a

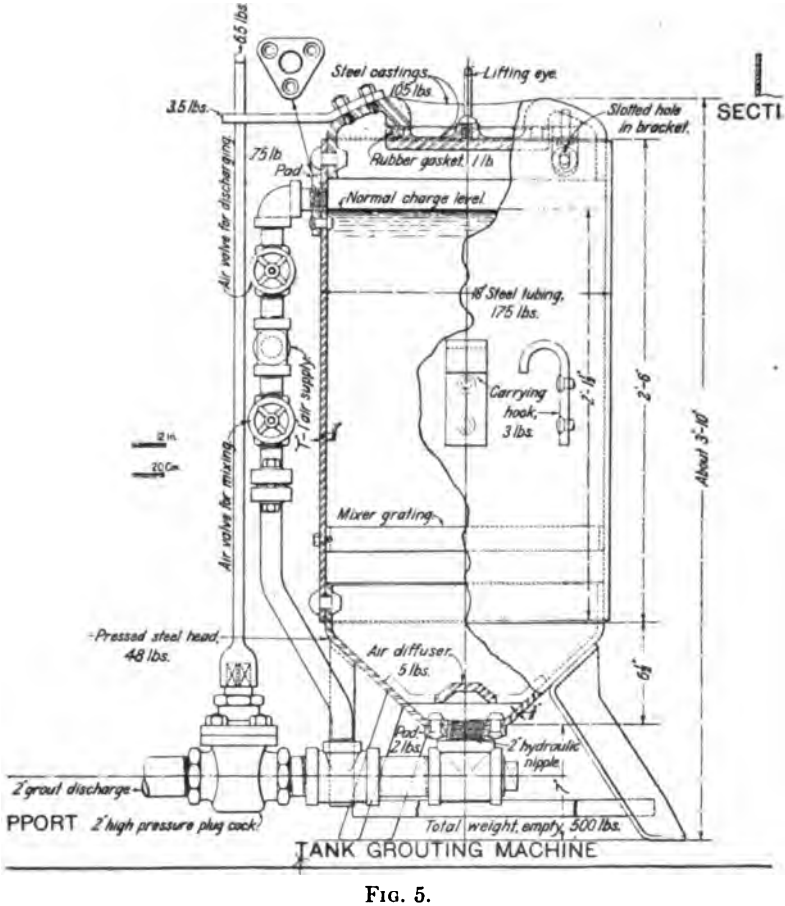


FIG. 5.

sack of fine sand are poured in, the air connection at the bottom is opened and the air allowed to bubble through and mix the grout. Then very quickly the door is closed, the lower air connection is closed, and the discharged connection and the upper air connection are opened and the air enters and drives the grout into the cavity.

A man stationed at the 1″ stop-cock keeps opening into a crack; when air shows instead of grout he closes the 2″ stop-cock and the machine is recharged. If the cavity is open the charge is pushed in in three or four seconds, and by working continuously over a thousand batches can be placed in twenty-four hours.

In one hole on the Aqueduct we put in 4,000 sacks of cement before we got the fissure filled up. In Shaft No. 4 we put in about 100 in the first fissure. A little further down in this shaft we encountered a layer of sand. The rock is folded very much; the sand was formed by the crushing of the rock due to the folding, was

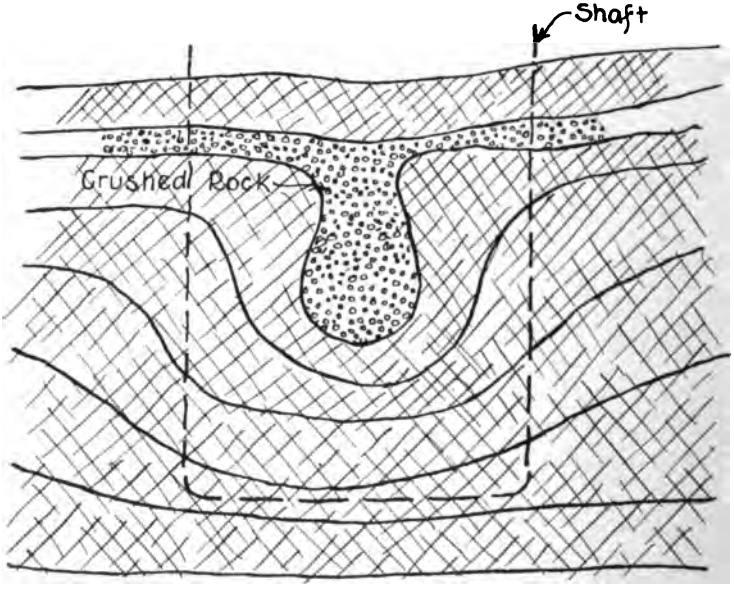


FIG. 6.

pretty fine and was carried up out of the drill holes by the water. Grout will not permeate sand and we had to continue drilling holes and pumping in grout, boosting the pressure at the end from 100 to 400 and 500 pounds to the square inch. We tamped that sand so full of cement that when we sunk through it it was compacted like sandstone. We found big balls of grout when we cut through it, some as big as a man's fist and some as big as his head.

The most interesting piece of grouting was done on the Hudson Siphon, which, as you know, is a deep siphon tunnel under the

Hudson River; 14 feet diameter inside the concrete lining, and at a depth of 1,100 feet below tidewater. There was practically no water in the rock and the shaft sinking was done by the City forces. When they got to the bottom they concluded it would be cheaper to turn the job over to a contractor, and this contract was let to The T. A. Gillespie Company. On the east side of the river the city had driven 200 feet of tunnel through perfectly dry rock when they broke into a stream of water which flowed 300 gallons a minute. They struck it at night, and the shift boss shot his holes and broke away all the rock that should have been there to fasten the grout connections to. When we got the job we saw the next thing to do was to build a concrete bulkhead. We boarded up the face and put in 8 feet of concrete across the full tunnel section (at this point a top heading 7 feet high and 14 feet wide) and then reinforced it with rails. The concrete was mixed 1 : 2 : 4. We let the concrete set for a week and then started grouting. Grout pipes were put through the bulkhead, terminating in the fissures. At an elevation of 1,100 the hydrostatic pressure is 500 pounds per square inch, and we had hard work to force in any grout against it. We had eventually to raise the pressure to about 1,000 pounds per square inch, and to do this we had to use a high pressure plunger pump and pump water in on top of the grout in the tank. We put in two carloads of cement into that hole, and after it was set up for a week we shot the bulkhead out and went ahead with the tunnel.

The contractor for the lower end of the City Tunnel in New York has encountered a good many streams of water at depths up to 500 feet, and has grouted them successfully.

Where we met the sand bed in Shaft 4 we were unable to get the water entirely shut off and we had to rely on the concrete lining to get the shaft entirely dry. In good rock as in the Hudson Siphon a concrete lining is not needed in order to cut off most of the water because if you drill into the seams you can grout them off. On the other hand if the rock is very much fissured it is practically impossible to grout it. When this is the case it is necessary to design a concrete lining strong enough to withstand the total water pressure that can come against the outside. In the case of an elliptical shaft that lining has to be thicker on the sides than at the ends; you can figure the stresses on the concrete if you are a good mathematician. We have found that 1-2-4 concrete 18″ thick in a 14-foot tunnel will stand 600 pounds to the square inch. Anything higher than that broke it.

If you met a little stream, just a few drops a minute, a pipe must be set in opposite that stream and the water led through the lining. After this concrete has set up two or three weeks and got good and hard you connect the grout machine to this pipe, drive a little grout in and stop the water. It is absolutely impossible to stop water coming through concrete when it is soft. You have to provide a drain until it sets. In one case we overlooked a small spring and after we had concreted about 60 feet of shaft above it, we notice the forms bulging over an area of about 10 feet square. We found that the accumulated pressure from the little spring had pushed the lining out over this area and we had to cut it out and replace it.

The question of a water-tight lining brings up the shape of the shaft. The shaft with the maximum area and the minimum lining is of course circular and this is by far the cheapest shaft to sink. That was brought out on the aqueduct. All the construction shafts at first were made rectangular and lined with timber while the waterway shafts were made circular. On the Rondout Siphon shafts we started out with the idea that the rectangular shafts would be easier than the circular, but it was the other way. When we started the first circular shaft we did not do much the first month. The last month we made 138 feet. The next siphon we moved to we had the same gang, and they knew how, and jumped the progress up to 170 feet in one month in shale. The same gang was then moved across the Hudson River to a granite shaft and we made 183 feet, which is the American record.

The way it was done is this:—The drilling is all done on one shift. Enough drills are put into the shaft so that all the holes in the round can be drilled and the sump loaded and shot in eight hours. The other two shifts clean out the shaft and get it ready for the drilling shift the next morning. We drilled 33 holes to a round.

The same method is used in South Africa on rectangular shafts, but in this country it has not been successful in rectangular shafts. I personally have tried it in four shafts and it would not work. However, in circular shafts we tried it and made it work.

I mentioned the rectangular construction shafts being slower to sink than the circular. In South Africa they hold the world's record for sinking and the shafts there are rectangular. In this country most rectangular shafts are about 12′ x 26′ and about ten to twelve men are carried on a shift. There will be two or three drill

runners, three helpers and about six muckers. In South Africa they use 35 to 40 men on a shift in a shaft of the same size. I was talking to a man from South Africa who had been engaged on some of this sort of work out there, and I asked him how he could get so many men in. He said they use Kaffir labor. These Kaffirs wear no clothing to speak of, and the temperature gets up to a great height with thirty or forty men all bunched together; they sweat and their greasy bodies just slide past each other without any trouble. He said that the smell down there is so strong that when a little bit of rock is dislodged, it just shoots right up out of the top of the shaft of its own accord.

Wherever the entire area of a circular shaft can be used, as for ventilation, a circular shape is best. Where this is not practicable, as in a hoist shaft with several compartments, the best plan is to cut the ends off the ellipse adopted by the U. S. Coal & Coke Company and make a compromise between an ellipse and a rectangular out of our circular arcs. In dry or moderately dry rock the concrete lining need not be over 15″ to 18″ thick, but in wet and seamy rock it must be thick enough to resist the hydrostatic pressure after the shaft is lined.

In New York City lately the contractors have been putting in as high as 25 to 30 feet of concrete in a day in a 14-foot circular shaft, and in six days, including getting started, putting the forms in and taking them out again, they will put in 100 to 120 feet.

The cost of a concrete lining is greater than the cost of a timber lining by just about the cost of the cement. As a rule, concrete outside the cost of the cement can be put in for the price of the timber; you have to pay for your cement and you have a permanent lining.

I do not know that I have shown just what the printed circular stated, but I think I have demonstrated the superiority of a particular type of shaft. By a comparatively small expense and proper preparation, it is possible to make a water-tight shaft and a safe shaft with no delay; we do away with the expense and danger of handling big quantities of water from shafts while they are being sunk, and we do away with the heavy fixed expense of pumping after the mine is completed.

DISCUSSION

MR. ELI T. CONNER.—I have been greatly interested in what Mr. Donaldson has told us, and particularly in the methods followed and the success he has met with in sealing off water. That is the greatest difficulty that we have all experienced. We have had to put down shafts in the coal region. I know of one particular instance where the scheme, and perhaps the ultimate success of the operation, has been entirely killed by an excess quantity of water. When I say "killed," I mean the cost of cutting through the water-bearing strata has burdened the enterprise with such a large amount of capitalization that I doubt whether it will ever work out. If the schemes we have just heard of had been used, in that particular instance, perhaps $200,000 might have been saved, and a long life of pumping. This expense will be there as long as the operation is continued.

MR. DONALDSON.—I believe I know the operation to which Mr. Connor refers. If so, I was on the job when they were sinking it. The shafts were only 300 feet deep and we had 750 H. P. in boilers that were working to about 200 per cent overload. We could not haul in enough coal to keep them going. The proposition was just open and shut for grouting. The contractors could have saved $50,000 on that job if they had known enough to ship in three or four carloads of cement. The seams were open and it was a hard sandstone rock with very well defined seams. When we drilled into them we got water spouting out from maybe eight or ten different holes. It was ideal for sticking on a grout machine, but we did not know it then. There was a water fall coming out of one corner of the hoist shaft—a man could get in behind it—and that seam would have taken probably two or three carloads of cement, which at that time was costing perhaps $1.50 per barrel. It would have cost perhaps $1,000 to caulk that seam, while it actually cost us about $40,000 to pump it, and the last I heard of the Mining Company they were financially embarrassed.

MR. SWAAB.—Have you succeeded in shutting the water off by the concrete system after you have gone by a spring?

MR DONALDSON.—Yes, but after you have gone by you have to line it. On the Aqueduct the shafts have to be absolutely watertight and the engineers will not permit a leakage of more than three, four or five gallons per minute. Although we did not have any large quantities of water to handle—perhaps 150 gallons—that has been entirely shut off in our Yonkers tunnel, and you can go down into the shaft in a dress suit if you want to. I have seen places in tunnels where we had an area of perhaps 40 feet in length covered with tin and sheet iron; where water was coming in in every pore, and the only way to stop it was to cover the whole patch with iron, lead off the water through three or four pipes, bring it through the lining, and after the lining was set up, to push grout in through the pipes. The lining had to be strong enough to resist the hydrostatic head of the water and the grout pressure. We have succeeded in cutting water off in that way in the Hudson Siphon.

MR. CONNER.—Where you went through sand, was that in the nature of quicksand?

MR. DONALDSON.—I have never met such a thing under rock. I believe that in Europe under this magnesian limestone they have quicksand, but we do not have any in this country. This pocket that I spoke of was where the rock had folded and had crushed itself. The fold is shown on Fig. 6. The grout will not permeate the sand, and we drilled a great many holes. We forced grout in with a booster under 500 or 600 pounds pressure. That would make a series of grout balls, and when we got through we had that sand seam packed full of these balls of grout. We did not get it entirely tight at that. Before we started in we would open up three or four holes at once and get nearly 600 gallons of water per minute and then plug them quick before the shaft was flooded. When we got through grouting we simply sunk through the sand, cut into the solid rock below, started what the Englishmen call the wedging curb, put corrugated iron clear around the wet section, inserted drain pipes, placed the lining and left it finally as dry as this ceiling.

MR. CONNER.—From that experience would you think that the system might be applied to quicksand such as is encountered in the Wyoming Valley?

MR. DONALDSON.—No, sir; it would not fit. If you had your quicksand in between two layers of rock as we had, where it could not get out, it might fit; but where it is a case of overburden, I do not know how you could grout that.

DR. CHANCE.—Just how long has this system of grouting rock fissures been introduced?

MR. DONALDSON.—As far as my experience goes, it was introduced four years ago.

DR. CHANCE.—I mean abroad.

MR. DONALDSON.—The first account I could find is about eight years ago, and in that case they struck water in large quantities; they put in an elaborate system of pipes and did not get the water cut off at that.

DR. CHANCE.—They were attempting to grout the fissures?

MR. DONALDSON.—Yes, only they tried to take it from up above, as we did at first, instead of from the bottom. I have a great respect for the European engineers, and I do not know why they did that.

DR. CHANCE.—The speaker has been entirely inconsistent. He told us in first place that European engineers were far ahead of American engineers, and now he tells us that he has succeeded where the European engineers failed.

MR. DONALDSON.—I will have to modify my remarks. In soft ground work they have us beaten.

DR. CHANCE.—That is because of the geological conditions, which are different abroad from those in this country. In certain places we have similar conditions, but we have so much coal and other minerals within easy reach of the surface that we do not have to go to difficult locations, as for instance below the sea, as they do abroad.

But it seems to me that Mr. Donaldson has given us a paper of very great value. I do not know that anything like this has ever been published; if it has, I have not read it. It seems to me that it is not only interesting, but is valu-

able to the engineering profession, and it is quite an achievement to grout rock crevices and lute them just as nature has luted most of our fissures of clay. The underground is generally dry after you get below the surface water, and that is due to the fact that nature has closed most of the crevices of the rock with sediment and calcareous deposits. This process of Mr. Donaldson's is a process not entirely dissimilar to that of nature, an artificial closing of the fissures so that they become impervious.

Mr. Donaldson has undertaken a hard task if he tries to persuade American engineers that a circular shaft is better than a rectangular shaft. From the point of view of first cost, he is undoubtedly right. But many other conditions must be considered by the engineer apart from the question of first cost. If a shaft requires lining, and if he decided to line it with concrete rather than with timber (for the purpose of eliminating fire risk, etc.) to remove the dangers which follow from explosion and the consequent destruction of mine timber, all right; then the idea that a circular or elliptical form is going to be cheaper is erroneous, because, depending upon the size of the cages used, in lining a rectangular shaft where the rock is fairly well able to sustain itself, the grout lining would have to be very heavy and sufficiently strong to withstand very heavy pressure. In such a shaft concrete partition can be used to divide the shaft into compartments. These will act as walls and support the lateral faces in a large shaft. A shaft having four or six compartments is a relatively long opening, and if the rock is badly fissured or requires timbering, with the square system of timbering there is no difficulty in supporting the side walls. If you attempt to support them with concrete, an elliptical form is best, provided you are not going to cross-brace. The rectangular system lends itself well to cross bracing, so it is doubtful if American engineers will come to use circular or elliptical shafts.

MR. DONALDSON.—The circular shafts certainly seem to be the correct construction where you have only one compartment in the shaft and where it is designed for carrying air. For long shafts I agree with the gentleman who has just spoken. For a 2-compartment or a 3-compartment shaft, the compromise section I sketched is cheaper than cross-bracing. Where you have a 4- or 5-compartment shaft, it is a difficult question to make an ellipse out of that, because you would have to take in the whole surrounding country. I think it would be cheaper to put in an iron and concrete lining and cross-brace it in the middle, and sort of arch the ends. It is a good deal cheaper lining if you can get one continuous stretch of forms around the outside.

MR. S. M. SWAAB.—On the aqueduct, were those shafts driven on the center line?

MR. DONALDSON.—The circular shafts were driven on the center line.

MR. SWAAB.—Is it not considered good practice to drive the shaft off the center line?

MR. DONALDSON.—Where there are rectangular shafts the two compartments were not quite above the center line of the tunnel. They moved it enough to get the center line away from the buntons.

MR. SWAAB.—It seems to me that if Mr. Donaldson finds he has sufficient time—he has done some work in this country which I believe was not done before—we would like him to tell us about it. Of course, it is the same process as was used in Europe in driving the Alpine tunnels, but Mr. Donaldson has driven tunnels by that bottom heading method in New York, and I would like to ask him if he would not say something about that, and the typical way of working. I have been in bottom head tunnels and could not see a whole lot of advantage in that method.

MR. DONALDSON.—I agree with Mr. Swaab; I don't either, and I would not do it again.

On one section of the aqueduct it was figured they would drive the heading clear through first, working the maximum economy, as cheaply as they could, and then take the bench out. I believe where you have good hard rock it is cheaper to drive the bottom heading and slope the roof down. I know that we abandoned the method that Mr. Swaab referred to—that is shooting the roof down on timbers at the same time we were driving the heading—we went ahead with the bottom heading to the end of the tunnel and then shot the roof down on the floor and mucked it by hand. While we were taking the roof down, Rinehart & Dennis, having driven the top heading, were removing their bench. We doubled their progress, taking out twice the material. In other words, the stopping method was about fifty per cent. better than the bench method for enlarging the section, but where the two things are going on simultaneously, the method of shooting the arch down on timber is not intended for the American tunnel man.

MR. E. E. KRAUSS.—Mr. Donaldson referred to the use of concrete for lining of tunnels against high water pressures. It would be interesting to know what proportions were used for the concrete and as to whether special measures were taken to obtain a concrete of maximum density, as I understand no waterproofing material is used in tunnel lining work of the character described.

MR. DONALDSON.—No, nothing was used.

MR. KRAUSS.—With 1—2—4 mixing?

A.—1—2—4. But we used 1—1½—3 in the Hudson Siphon.

MR. SWAAB.—Did you use any lime in the cement ground at all?

MR. DONALDSON.—No, but in the Pennsylvania River Tunnel I understand they used considerable English lime.

MR. SWAAB.—Of course, that was just for filling up the spaces around the shield.

MR. W. C. FURBER.—I would like to ask Mr. Donaldson if he will describe in a little more detail the instance he cited where they faced the fissures in the rock, the preparation of the sleeve or concrete lining; just how was that done?

MR. DONALDSON.—Just before the Hudson Siphon was turned over to the contractor, the City forces drilled into quite a stream of water in the heading. Instead of attempting to grout off the water, they shot the cut and got a strong flow from the cavity. When we took the work this stream was flowing, and we

had to build a strong bulkhead so that grouting would be possible. We stuck a pipe into the fissure at the bottom of the cut and drained the water through it, then built a bulkhead of concrete 8 feet thick across the entire face of the heading. The bulkhead was heavily reinforced by rails set into holes drilled in the ribs. We provided additional grout pipes through the bulkhead after the concrete had set for a week, grouted all pipes at pressures up to 1,000 pounds per square inch, completely cutting off the water. When driving was resumed no water was encountered.

MR. FURBER.—That grouting was sufficient to fill up the fissures, was it?

MR. DONALDSON.—Yes, we put in about three carloads of cement.

PAPER NO. 1130

THE DESIGN AND CONSTRUCTION OF THE HYDRO-ELECTRIC PLANT AT ESTACADA, OREGON.*

BY HERMANN V. SCHREIBER

Read March 15, 1913

The extremely heavy precipitation on the nearby mountains and snow peaks, combined with the high fuel costs along the northern portion of the Pacific Coast, give us conditions very favorable for development of large hydro-electric transmission projects. Several of such projects center about Seattle and Portland, and other systems are being developed around the smaller cities.

At Portland the Columbia river, which is the largest stream in the northwestern section of the United States, breaks through the Cascade mountains and flows westward to the Pacific past Portland, where it is joined by the Willamette river flowing from the south. Both these streams and some of their branches are navigable and also provide considerable power. Flowing from the east into the Willamette river south of Portland is the Clackamas river, which finds its sources among the peaks of the Casca Range south of Mount Hood. This river, being fed from several snow covered peaks and forest reserves, has a comparatively steady flow, and because of its rapid fall and high banks offers numerous attractive power sites.

The Portland Railway, Light & Power Company, controlling the electrical market in and around Portland, having already acquired a development on the Clackamas river about 40 miles southeast of Portland with an interurban railway connection partially paralleling the streams, naturally investigated the further possibilities for development on this stream as soon as their increasing load conditions indicated that they would require more power than their existing plants could produce.

---

*Portion of Paper presented to the National Association of Cement Users at Kansas City, Mo., February, 1912.

Messrs. Sellers & Rippey, Consulting Engineers, having been requested by this company to study the situation, made a careful investigation of the stream flow conditions, and it was found first that the annual rainfall was extremely high, but there was a dry season during the summer when no precipitation whatever occured over most of the drainage basin. From the few years' records available, however, it was found that the stream flow during this dry season was very well maintained, apparently from the melting snows of the mountain peaks, and while one or two large floods were recorded they did not appear to be excessive in view of the extremely heavy precipitation. After considering these conditions it was determined therefore that while a seasonal storage would be advantageous the flow coincided sufficiently well with the ordinary electrical load conditions that additional power developments could be justified at once.

The peculiar rock formation due to the geologic history of this country was next given consideration. Several extinct volcanic peaks are included in this portion of the Cascade Range and the discharge from these peaks has covered the country with various forms of volcanic lava and débris which is of such a porous and uncertain nature that it introduces serious obstacles to satisfactory hydro-electric development. Taking up the matter with Mr. J. S. Diller, of the United States Geological Survey, who made a special report on this river, we secured the following information:

"The volcanic breccia (bed rock) is made up of unassorted angular fragments of lava andesite and basalt of various colors, ranging in size from dust particles and grains of sand to large rock fragments many feet in diameter. This fragment material was blown by explosive eruption from the volcanic crater higher upon the range and fell upon the mountain slopes where it became so saturated with water from the copious rains accompanying the eruptions that it flowed in great steaming sheets from the Cascade Range to the gentle slope of the plains, in much the same way as similar material flowed down the old stream channels on the western slope of the Sierra Nevada in California, and covered the early and often rich deposits of auriferous gravels.

"Sheets of solid nonfragmental lava forming part of the bed rock and outcropping on the slopes of the canyon occur within and between the great sheets of volcanic braccia. Some of the lava sheets are basalt, others are andesite and they are usually less than 30 feet in thickness. The basalts are generally very porous and gray or dark. The andesites are often reddish and porphyritic with white crystals of feldspar."

Speaking of the cracks in the lava, Mr. Diller called our particular attention to those which cut up through the volcanic breccia and sheets of lava about vertical in a direction approximately parallel to the course of the canyon. Such joints, he stated, may be of considerable extent and form important openings for the circulation of water.

This report together with our own examinations indicated that any extensive hydro-electric development should be provided with a substantial cut off at the base of the dam, and because of this feature together with the variable bearing values, some form of hollow dam would probably meet the general requirements better than the standard form of solid dam.

Examining the various sites available along the river above and below the existing plant, we found one site about two miles upstream at which the superficial conditions appeared to be good enough to justify further sub-surface investigations. We then immediately started several core drills at work drilling holes, some as deep as 250 feet, over the entire space which was available for location of a dam. While this work was proceeding the growth of the power market indicated that a smaller plant, possible of quicker construction, would have to be provided before the plant proposed for this site could be built, and it was therefore suggested that additional investigations should be made elsewhere along the stream to determine whether any other site might be available for immediate development.

After a review of the conditions downstream a site was then selected near Estacada, about 5 miles below the existing plant, where propects for quick and economic development seemed to be quite favorable. Core drillings at this point, covering four possible locations, indicated that one of them, containing an island which would be included in the construction, might considerably reduce the amount of material required and at the same time make the construction much more convenient by facilitating the diversion of the stream during the rainy season. After the preliminary core drilling had been completed this site was decided upon for immediate construction and the particular type of hollow dam best adapted to the consideration.

Our previous experience in this direction, together with numerous studies of comparative costs and other inherent advantages in various types of hollow dams prompted the selection of the Am-

FIG. 3.
Dam in Course of Construction.

bursen type because of the availability of an experienced construction organization which could be started at once on the work and push it to completion without delay.

While this dam is a patented device we have always found the designers glad to coöperate in thorough analysis of the factors entering into the design in each case, and we have found this to be good policy because of the advantage to our clients in thus securing a more thoroughly worked out and carefully considered design. The dam consists of a series of buttresses running parallel to the thread of the stream and covered on the upstream and downstream sides with a reinforced concrete deck which is carefully embedded in the foundation material on the upstream side and curved so as to throw off the water on the downstream side. The upstream portion, known as the deck, is inclined 45° with the vertical, having a thickness varying from 20″ to 48″ on a spacing between buttresses of 14 and 18 feet. The apron or downstream portion of this cover makes an angle of 30° with the vertical and has a thickness averaging about 18″ The deck and apron are both reinforced by horizontal corrugated rods and additional rods placed vertically as an extra precaution against weakness in joints and temperature strains.

The buttresses in the rollway section are spaced 18 feet on centers, and in the power house or intake section 14 feet on centers, the thickness varying from 15″ to 38″ with special spread at the base in proportion to the load imposed. These buttresses being built in horizontal lifts of 12 feet, are reinforced at the bottom of each lift and at the top of each lift as a precaution against temperature strains and low bearing value of foundations. The upstream ends of the buttresses are provided with haunches, which give 18″ seats for deck slabs and provide a tongue between the haunches on each side, so that the deck slab is not continuous through the crest. The apron slabs are laid directly across the buttresses and are continuous.

This general description covers the usual hollow dam of this particular type, and as constructed at Estacada there were added a series of sluice gates together with the usual closing device in the left or main river channel and on each end of the construction there was provided a suitable reinforced concrete abutment. Across the top of the island, which subsequently was discovered to be of comparatively little value, the construction was continued and so extended as to protect the island from erosion.

Fig. 4.
General View of Dam.

To the right of the spillway section, which had a maximum height of about 86 feet, the bulkhead section extended to a greater height of 15 feet and included on the left side of the island an intake section for five 11 feet penstocks. Immediately adjoining the intake section there was included a fishway tank and ladder of reinforced concrete which was built on the side of the island from the tailrace.

At the intake section an old gorge, apparently forming a prehistoric river bed, was uncovered extending about 30 feet below the ordinary river bottom, and it was necesaary to practically fill this with concrete to form a foundation for the dam and power house. The power house immediately adjoined the dam on the downstream side and contained five 6,000 H. P. turbines and 3,300 K. W. Generators with step-up transformers and high tension equipment located inside the bulkhead portion of the dam.

Access is provided by means of a railway connection extending out over the bulkhead portion of the dam into an enlarged portion of the gate house, where a crane is provided for unloading the cars and lowering materials to the power house floor level. From this point a small truck is provided to transfer these materials into the power house, where they are accessible by the power house crane.

The tailrace extends from the power house to the river channel, being specially excavated around the island to a point where there is the least possible interference from the spillway discharge. To provide adequate rack area the deck of the dam was set back and steel framing erected from the point of offset to the water surface. In this way space is provided back of the racks for easy access of the water to the intakes, and the head gates could be installed without unduly interfering with this access.

The penstocks are supported by frequent struts extending from the buttresses on each side, and, being 11 feet in diameter, leave little clear space between the buttresses, which are spaced 14 feet on centers. The intakes for these buttresses are supported by an extra thickness of deck, with additional reinforcement in the deck and buttress to withstand vibration during operation.

Because of the extreme flood conditions the power house foundations are of solid concrete with flood protection for a height of 14 feet above the floor level. The penstocks enter the turbines beneath the floor level through a large cast iron Y pipe, and the twin volute cast iron casings on the turbines discharge into a

central cast iron draft tube which passes out through the foundations into the tailrace.

The generators are provided with ample ventilation and have a direct connected exciter on the outboard end of each shaft. To each generator there is direct connected a 3 phase 60 cycle 33,000 volt delta and 57,000 volt Y transformer located in the alternate spaces between the penstocks. The buttresses immediately above them are provided with necessary busbar compartments for high and low tension busbars, oil switches, lightning arresters, etc., providing connection to the transmission lines to Portland.

In the design of the dam the following materials and stresses were specified:

Concrete—Deck and Apron 1:2:4
Buttresses 1:3:6

Reinforcing steel—Johnson corrugated square bars 50,000 pounds elastic limit and 80,000 to 100,000 pounds ultimate strength.

Stresses—Modulus of elasticity of concrete 1,500,000.
" " " " steel 30,000,000.

Compressive stress in concrete	500 lbs. per sq.in.
Shear in concrete	75 " " "
Tension in concrete	0
Tension in reinforcing steel	15,000 " " "
Base pressures	100 " " "

Before beginning actual construction it was, of course, necessary to determine definitely the proper method of reducing, as far as possible, the seepage through the porous foundation material. In this consideration we had the benefit of quite extended borings at the upper site, together with several experiments made at that point, but were unable to find the same conditions had been met and satisfactorily treated elsewhere.

The most definite and positive cutoff wall which could be provided would, of course, be a steel or concrete diaphragm across the entire width of the dam site, and several schemes were worked out to demonstrate the feasibility of such a construction, but as the cost would be large and the time required would be considerable a modified scheme was finally installed providing for three rows of holes to an average depth of 50 feet, all of which were pumped full of cement grout under high pressure.

In considering any modified or compromise form of cutoff wall the integrity of which was not self-evident it was necessary to provide some means to demonstrate its efficiency because of the importance of the work involved. The purpose to be served by such a cutoff wall was first, to minimize the upward pressure; second, to prevent percolation; and third, to overcome any structural weakness in the foundation.

In the form of cutoff wall finally adopted the holes were spaced in three rows, each 6 feet apart. The outside rows of holes were drilled first and the grout pressure applied by means of a Canniff Pneumatic Grout Mixer and Injector until the pressure rose to 200 pounds if possible. Each hole was drilled and grouted as soon as completed, some of the holes requiring a considerable quantity of cement, while others could not be entirely tightened, and permitted the pressure to be raised to only about 50 pounds. At times the grout would escape to the surface and in those cases it became necessary to discontinue grouting on that particular hole until the cement had somewhat hardened when pressure was again applied.

Following the drilling and grouting of the outside rows, holes were drilled along a row midway between and pressure applied without grout in order to test the efficiency of the diaphragm formed by the grout as distributed from the first set of holes. Where the results were not satisfactory additional holes were drilled in the outside rows and after grouting further tests were made along the center line of holes until satisfactory results were secured. This cutoff wall was located immediately upstream from the point at which the deck joined the river bed, and after completing the drilling and grouting the river bed was excavated for a depth of 4 to 6 feet and solid concrete filled in and joined to the concrete of the deck in order to form a complete impervious cutoff wall.

After the completion of the dam and filling of the pond two holes were drilled into the river bed inside the dam about 30 feet downstream from the cutoff wall, which gave a static head within 13 feet of that due to the water in the pond.

A careful examination of the river bed below the dam during the period of filling indicated that the seepage was not sufficient to cause excessive erosion, and there is reason to believe that the gradual deposit of silt in the river bed above the dam will practically eliminate such seepage as does occur. To complete this work

required drilling of 34,000 feet at a cost, including grouting, of $1.55 per foot.

The scarcity of suitable construction materials necessitated a careful investigation, with the result that a satisfactory sand bank was uncovered and arrangements made to select stone from the only available quarry along the railway right of way. The cement business on the coast not being in an entirely satisfactory condition, a careful investigation of all the principal plants which might furnish material for the work was made, with the result that a satisfactory contract was closed for sufficient material to contruct this work and meet the general construction requirements of the company for several years afterward.

The construction equipment included steam drills, derricks, cableways and narrow gauge railway system, together with the six core drills, air compressers and grouting tanks. Three concrete mixers were erected with suitable supply and storage bins, and a large construction camp was established.

The work first proceeded with the uncovering of bed rock material on both banks and on the island above the water line and it was discovered that the island did not prove to be as great an advantage as was at first expected, because of the existence of an old stream channel and a considerable quantity of clay on one end. This condition, together with the necessary excavation of an old river channel at the site of the power house, greatly increased the excavation above the amount expected.

The first concrete work was begun along the right hand river bank and the first lift of one buttress was erected in the middle of the right hand channel in order that it might serve as one portion of a coffer dam to divide this channel, when the work was being completed. By locating the cutoff wall several feet upstream from the base of the dam, it was possible to proceed with the drilling and grouting practically independent of the main portion of the construction.

Across the island this cutoff wall was extended through a slot excavated in the island almost to the water level with a sloping downstream face, which when covered with 2 feet of concrete formed the upstream deck of the dam at this point.

The entire construction from beginning of excavation to delivery of power at Portland required approximately 17 months, the largest force employed at any time being 655 men. In the construction

of the dam the buttresses were built in lifts of 12 feet, groups of three and four buttresses being built at one time according to the space which was available for this purpose. The deck and apron was usually placed on the buttresses soon after completion of each lift, so that in this way with the struts between the buttresses each buttress was properly supported as it was erected.

At the power house site after the whole chasm had been filled up the foundations were erected to the point where the penstock elbows and draft tubes could be placed, then the additional concrete was placed up to the floor line. The end walls of the power

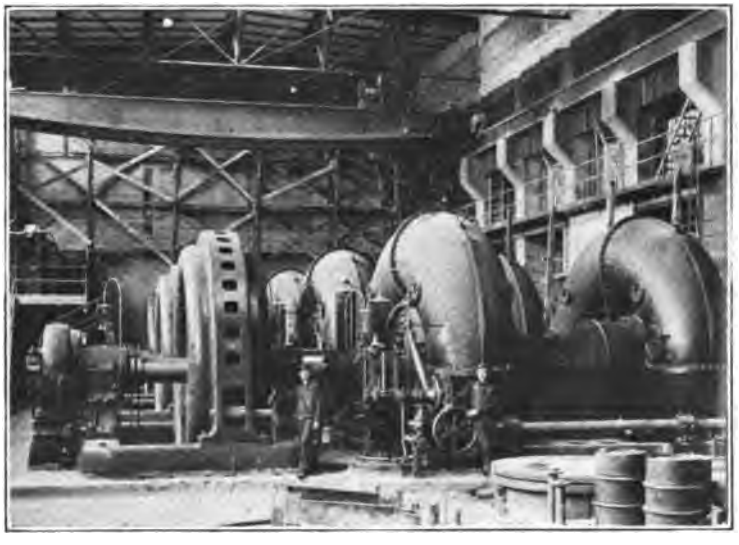


FIG. 5.
Interior of Power Station.

house formed protecting walls along the river bank on one side and the island on the other side. The reinforced concrete superstructure of the power house and gate house was further stiffened by structural steel framing to support the cranes and roof trusses.

The work proceeded during the entire construction period, though its progress was somewhat interfered with by the heavy rains of the winter season. Fortunately, however, there were no excessive floods, and the cofferdam problems were not serious. The closing of the dam was effected after completion of the entire

structure with the exception of its temporary openings through the base of the spillway portion, which together with the three sluice gates carried the entire stream flow during the dry season just preceding the completion of the structure.

The installation of the machinery was pushed along as rapidly as the completion of the dam permitted. On account of the location of the power house with respect to the dam, it was necessary to lower the apparatus from the top of the bulkhead to the power house floor level, and the erection of the high tension apparatus inside the dam required that the buttress in back of the power house be completed and properly covered before installing this portion of the equipment. This was done, however, and as the transmission line was completed about the same time it was possible to transmit power to Portland very soon after the water was first passed over the spillway.

Mr. Frank R. Fisher, a member of your club, who was Resident Engineer in charge during the construction, kindly furnished much of the construction data given above.

PAPER NO. 1131

SUCTION GAS PRODUCER PUMPING ENGINE VS. COMPOUND CONDENSING CORLISS CRANK AND FLY WHEEL PUMPING ENGINE, GIVING COST OF OPERATION AND FIXED CHARGES, BASED UPON FIVE YEARS' OPERATING EXPERIENCE

BY J. E. GIBSON AND S. H. WRIGHT

Read May 17, 1913.

We are all familiar with the cross compound connecting Corliss engine, direct-connected to a pumping unit by having the piston rods extended back through cylinder heads, or by a set of trombone rods passing over crank and connected to the plungers of the pumps, and it is, we believe, generally conceded that this type of pump ng engine is about the best where efficiency, long life, simplicity of design and operation are considered.

On the other hand, we know comparatively little in this country about the gas or oil driven pumping engine. Among the principal reasons for this condition we may mention the following:

1st. The conservatism of the American engineer and owner against adopting something new and therefore different.

2nd. The early history and experience with the American built gas engine.

3rd. The difficulty of obtaining experienced help familiar with gas engines and producers.

4th. The low first cost of steam driven pumping engines as compared with the cost of gas engines.

5th. The abundance and low cost of fuel, making economy of secondary importance.

However, the increasing cost of fuel and the agitation for the conservation of our natural resources, together with the improvement in design and construction of the American gas engine, has caused a decided change in the attitude of the engineer and owner toward the gas and oil engine prime mover.

There is an abundance of engineering literature, technical and descriptive, on the gas engine, its thermodynamic and mechanical efficiency, reliability, first cost, maintenance, etc., but we do not recall anywhere a comparison of this type of prime mover with that of steam upon a commercial basis and especially one covering any considerable interval of time.

In the following we hope to present some figures that, while not technical nor bristling with B. T. U.'s, will be both useful and enlightening. Before proceeding to that portion of the paper, however, a brief description of the two plants to be considered will be given.

Delaware Water Company Plant.

The Delaware Water Company was organized some seven years ago and supplies water to the P. B. & W. R. R. at its new shops and yards at Edge Moor and other points as far south as Newark, Delaware.

Its pumping station is located at the head of tide water on the Christiana Creek, where an old water power driven feed and flour mill is located. This property, especially the dam, had been allowed to decay, and, in fact, shortly after the water company purchased the site, a sudden freshet washed the old dam out. This was replaced by a new concrete dam 200 feet long by 12 feet high, built on heavy timber crib work and flanked upon each end with earth embankments.

Christiana Creek has a rather tortuous course through a sandy clay water-shed of 47.75 square miles, at site of dam, of which 85% is under cultivation. Generally speaking, the water is very turbid and high in suspended matter.

The impounding dam (10,000,000 gallons storage) is too small to permit of any material sedimentation, so mechanical filtration was resorted to.

The water flows from the impounding reservoir through an intake chamber, where a portion of the coagulant is fed, and a 16 inch main to a 500,000 gallon capacity sedimentation basin; from here it flows to the main suction well, where additional coagulant is added when found necessary. The pumps lift the water from the suction well and discharge it through mechanical pressure filters to the standpipe and storage reservoirs of the Railroad Company.

Mechanical Plant.

Building.

The building for the plant is a neat, ornamental, brick structure, 130 feet long by 44 feet wide, concrete floors, slate roof on iron roof trusses, and divided by brick partition walls into producer, engine and filter rooms. Except for the producer room, which has a second or charging floor of rolled steel floor plate, the building is one story. Immediately to the rear of the producer room at the elevation of the second floor is located the coal storage bin. This is of concrete and rubble masonry walls, concrete floor and heavy wooden flat roof with coal holes. Coal is hauled from Bear Station on the Delaware Division of the P. B. & W. R. R. by wagons, which drive onto the roof and dump their load through the coal holes into the bin. Industrial tracks are laid in the bays of the bin, so that the operator loads the coal car in the bin and pushes it on a slightly descending grade to the producer room charging floor. This is a most admirable arrangement and dispenses with any form of mechanical elevator or lift. The ashes are taken from the producer at the lower floor and wheeled to the ash bin.

Gas Producer.

The gas producer plant as installed consists of two complete units of producers, pre-heaters, scrubbers, purifiers and their accompanying piping, drip wells, seals, etc. Each producer unit is equipped with a full set of manometers and a positive type of pressure blower for blowing up fires. This blower is belt-driven from a small water motor, or in case of insufficient water pressure can be operated by a hand crank attached to the extended shaft of the motor. Producers are the standard suction type and rated at 110 HP. by R. D. Wood & Company, their builders. The gas passes from the purifiers through a 16″ cast iron gas main into engine room, where the branches are taken off to supply the engines. The far end of the gas main is provided with an opening to the atmosphere. In starting the plant, the purge valves at producers are closed and gas is blown through the gas main and out this bleeder until all of the air is displaced by gas.

Gas Engines.

There are two 13″ diameter by 12″ stroke three cylinder, single acting, type 3, vertical Westinghouse gas engines rated by their

builders at 89 B. H. P. when operating at 290 revolutions per minute.

Engines as installed are actually operated at 265 revolutions, with proportionate loss of power.

Pumps.

Each engine has its crank shaft extended and direct-connected by flanged coupling to the pinion shaft of 13″ diameter by 15″ stroke, single acting, triplex Deane pump. To accommodate the alignment of engine and pump shafts the pumps are set in a pit about three feet deep. Each pump is fitted with a single reduction of gears of 6 to 1 ratio, and when running at 44.1 revolutions, has a capacity of 1,640,000 gallons per 24 hours. Each pump is fitted with large suction and discharge air chambers, relief valves and starting valves.

Auxiliaries.

Each engine drives a small belted air compressor for compressing air to a pressure of 250 pounds gauge. This compressed air is stored in a battery of three air tanks and is used to start the engine. In addition to these compressors a small gasoline driven air compressor was installed lest the compressed air storage be lost by accident or leakage. It may be of interest to state that no difficulty has been found in retaining air charges for a week at a time and ordinarily one charging is sufficient to make a half dozen starts. Of course, engines are started without load by opening starting valves on pumps.

Each engine is equipped with ½ kilowatt 110 volt generator and 6 cell Edison battery with necessary spark coil, resistance lamps, combination switchboard and fuse blocks for electric ignition.

Suction Discharge Piping Air Chambers.

Each pump has an independent suction pipe to suction well, and discharges through a 16″ connection to the 16″ main discharge pipe.

As the discharge takes place at times through a main 15 miles long, it was thought best to install a large steel air chamber at the back end of discharge main. This air chamber is 60″ in diameter by 12 feet high, and is charged with air from small air compressors used for starting engines.

Filters.

The four filters are of the pressure mechanical type, 8 feet in diameter by 25 feet long, nominally rated at 500,000 gallons each, or 2,000,000 gallons for the plant. Room was provided in the building for four more of the same size.

The discharge main is a compound pipe composed of two sections, the first 2.9 miles of 12″ and 16″ diameter and the second 12.1 miles of 20″ pipe. Located at the junction of the 12″, 16″ and 20″ pipes near Ruthby, Delaware, is a 50 by 50 foot steel standpipe, having its flow line elevation at 131. At Edge Moor, the end of the 20″ line, there is a 20,000,000 gallon reservoir having a flow line elevation of 79.3 feet. The pumping head when operating one pump against Ruthby standpipe is 140 feet, and against Edge Moor reservoir it is 117 feet; when operating two pumps against Ruthby standpipe the head is 168 feet and against Edge Moor Reservoir 173 feet.

All water pumped is measured by a Simplex Venturi type meter.

Method of Operation.

For the first year or so only one pump was operated, and for only a portion of the day, but now the consumption has reached that point where it is found advisable to operate one pump continuously and the second pump several hours each day. Accurate daily records are kept of all operating conditions, such as coal consumed, water pumped, oil used, amount of water flowing over the dam, etc.

Cost of Plant.

As this paper is dealing only with the Mechanical plant, no costs except those belonging to the plant proper will be given. The cost of the various items is as follows:

Land for pumping station site, exclusive of riparian rights, damages or other costs strictly belonging to the cost of obtaining a water supply	$ 5,000.00
Building including coal storage bin, suction well, foundations for producers, engines, pumps, filters, etc	33,750.00
Gas producer plant, engines, gas piping, air compressors, air tanks including freight, hauling, labor and erecting	13,000.00
Pumps complete including freight, hauling and erection	7,250.00

Steel air chambers, suction and discharge piping complete, including all auxiliaries not included in above ..	4,500.00
Filters complete	13,750.00
Total cost of mechanical plant, building and lands	$77,250.00
Total cost of mechanical plant, building and lands, exclusive of filters	63,500.00
Cost of plant per B. H. P. as at present installed 162 B. H. P., exclusive of cost of filters	392.00
Cost of plant exclusive of filters per million gallon capacity per 24 hours	19,250.00

Fuel Used and Cost.

A good grade of anthracite pea coal is used, costing $2.75 per ton of 2,240 pounds at the mine. The freight from mines to Bear is $1.70, to which must be added the cost of hauling, amounting to 65 cents per ton, making the total cost of coal delivered in coal storage bins $5.10 per long ton.

It might be well to state here that it does not pay to purchase anything but the best grade of white ash non-clinkering coal, which must also be of a uniform grade as to size.

Performance Test.

The guaranteed test conditions were as follows:

When operating engines at 89 B. H. P. the consumption of coal was not to exceed 1.3 pounds per B. H. P. hour, and when operating the engines at 45 B. H. P. the guaranteed coal consumption was not to exceed these guarantees, the full load test being 1.02 pounds of coal per B. H. P. hour and 1¼ pounds per delivered water horsepower, equivalent to a duty per hundredweight of coal of 158,400-000.

We will for the present drop the gas producer plant and give our attention to the steam plant with which it is being compared.

OCTORARO WATER COMPANY PLANT.

This company was organized about 1903, and, as its name implies, obtains its water supply from the Octoraro Creek. There are two pumping stations, the first or steam station, with which we have to deal, located about three miles south of Quarryville on the west branch of Octoraro Creek; the other a water power pumping station located below the junction of the west and east forks at Pine Grove Forge, Pa.

The drainage area of the west fork at the location of the steam station is 23.0 square miles, of which about 80% is under cultivation. The drainage area is very free from contamination, and the steam is, generally speaking, very clear and free from suspended matter.

A masonry intake dam was constructed across the stream, forming a small pool and diverting the water to a suction well.

Mechanical Plant.

Building.

The building for the plant is a single story, ornate stone structure, 50 feet wide by 87 feet long, with gable ends and basement under engine room portion only. Roof is of Spanish glazed green tile laid on iron roof trusses, floors of concrete. The coal storage bin is located at the boiler room end and connected therewith by a covered passage. The coal storage structure is of stone, laid in conformity with the main building, and has a gambrel roof of galvanized iron. Coal is shoveled into the bin through openings in side walls of building. To avoid the lifting of coal in shoveling, the roadway around coal bin is elevated sufficiently to bring the bottom of coal openings at about the elevation of an ordinary wagon bed.

Boiler Plant.

The boiler plant consists of three 60″ diameter by 18 feet long horizontal return tubular boilers, with three pass brick setting in one battery. Each boiler contains forty-five 4″ diameter by 18 feet long charcoal iron tubes and 1,020 square feet of total heating surface. They were designed for a working steam pressure of 140 pounds gauge under the Philadelphia Rules of the Hartford Boiler Insurance Company, and are connected by a brick breeching to a 4 foot diameter by 108 foot high Heinicke radial brick stack lined throughout with fire brick.

Pumping Engines.

There are two 18″ and 32″ by 30″ stroke, horizontal, cross compound condensing Wetherill Corliss engines having their piston rods extended through the back cylinder heads and connected to two horizontal, double acting inside packed plunger pumps having 10″ diameter plunger and 30″ stroke, designed for a working pressure of 150 pounds per inch.

The engines are of the standard Corliss type. Cylinders are not steam jacketed, nor does the receiver have reheater coils. It will be seen later that the plant is an exceptional one for low maintenance cost, and has a remarkably high station running duty.

Engines were designed to run at from 55 to 60 revolutions per minute and were rated at 3,000,000 gallons capacity, when running at the lower speed. On account of the high piston speed, 300 feet at 60 revolutions, the valve area of the pumps was made large, 173% of plunger area, and large suction and discharge air chambers were provided.

Auxiliaries—Condensers.

Each engine is equipped with a surface condenser located in suction pipe to main pumps, and a 7″ x 12″ x 15″ independent horizontal single cylinder, double acting air pump, brass fitted throughout.

Feed Pumps.

Two 7½″ x 5″ x 6″ outside end packed ram pattern brass fitted feed pumps supply water to the boilers.

Heaters.

The exhaust steam of all auxiliaries piped to a 500 H. P. Cochrane heater.

Steam and Water Piping, Meters, etc.

Steam piping is complete in all details, special care being taken to prevent accidents, etc. Boiler steam supply outlets are equipped with double valves with bleeder between them, and in addition a quick closing valve is located in the main steam pipe, readily accessible to the fireman, so that in case of accident he can shut steam off from the engine room.

Complete Holly gravity system for automatically returning live steam drips to boilers was installed.

Main engines were furnished with independent exhaust to atmosphere and fitted with relief valves.

All live and exhaust steam piping where loss of heat is disadvantageous is covered with 85% carbonate of magnesia.

Water piping is flanged cast iron throughout.

Engines have independent suction pipes to suction well located just outside of engine room. No foot or check valves are used, but each air pump is connected with its respective suction air chamber

of main pump, so that suction pipe, condenser shell and suction chambers are entirely exhausted of air and full of water before engine is started.

The discharge main is 16″ diameter and 2.21 miles long. All the water from both the water power station and this station passes through this main to the 10,000,000 gallon distributing reservoir at Mars Hill, which has a flow line elevation of 728 above Sandy Hook. The elevation of the water in diverting intake dam is 427 feet above Sandy Hook, making the static head on pumps 301 feet. This head is increased to 335 feet, when steam plant alone is in operation and 365 feet when water power station is running at its full capacity.

In addition to suction and discharge air chambers, there is a 6 foot diameter by 14 foot high steel air chamber located at the back end of discharge main. A Westinghouse Air Compressor 9½″ diameter steam by 8½″ air cylinder by 10″ common stroke, for furnishing compressed air for all air chambers, is mounted upon the large steel air chamber.

Complete set of gauges, revolution counter and connections was furnished with each engine.

All water pumped is measured by a 16″ Simplex Venturi type meter.

Operation.

Usually one pump and two boilers are in use. The number of hours the plant is operated per day varies, owing to the changing consumption and to the amount of water pumped by water power stations. This latter amount depends entirely upon the flow of the creek.

Accurate daily records are kept of all operating conditions, as in the Delaware plant.

Cost of Plant.

As in the gas plant, no costs other than those belonging to the mechanical plant and its housing will be given:

Land for pumping station site, exclusive of riparian rights, damages and other costs pertaining to the securing of a water supply	$ 5,000.00
Building complete including coal storage bin, engine and boiler foundations, stack, grading, etc	32,875.00

Complete mechanical plant including boilers, engines, auxiliaries, steam and water piping, covering, etc	39,850.00
Total cost of mechanical plant	$77,725.00

This latter figure should be compared with the cost of the Delaware plant exclusive of filters, i. e., $63,500.00.

Cost of plant per B. H. P. of engine, allowing 10% for friction of engine	190.00
Cost of plant based upon total capacity in million gallons per day	12,100.00

Fuel Used and Cost.

The best grade of "B" or Miller vein bituminous coal from the South Fork region is used, costing $1.50 per ton of 2240 pounds at the mines. The freight from the mines to Quarryville is $1.50 per ton, to which must be added the cost of hauling, amounting to $1.40 per ton, making the total cost of the fuel delivered in coal storage bin $4.40 per ton. This coal is high in carbon, low in volatile matter and is one of the best steaming coals mined in Pennsylvania.

Performance Test.

The duty guarantee was to be not less than 100,000,000 foot pounds per thousand pounds of dry steam when operating at a capacity of 3,000,000 gallons per 24 hours against a working water pressure of 332 to 362 feet; the steam pressure, 135 pounds at the throttle. The steam consumption of the independent air pump is to be included with that used by main engine.

We have gone rather fully into the description of these plants, chiefly to give a clear idea of the two plants, so that individual conclusions may be made upon the matter to follow.

Operating Records, Expenses, etc.

As before stated, complete daily records of operating conditions were kept at pumping station. The more important and pertinent ones for this paper are:

1st. Fuel consumed.

2nd. Daily pumpage in gallons by meter.

3rd. Total pumping head, which included, 1st, suction head, 2nd, discharge head. (Plus or minus correction for difference in elevation of gauges. This was a constant, as gauges were permanent.

4th. Number of hours in operation.

5th. Other incidental records kept were steam pressures, vacuum, revolutions of engines, feed water pumped to boilers, oil waste and packing used, supplies received, operating force employed, and any other matters of probable interest.

All records pertaining to the expense of operation of plant were kept in the main office of the company. For the purpose of this paper it is not advisable to go into too much detail, so we have divided the operating expenses into the five general headings, as follows:

Fuel,
Oil, waste and packing,
Pumping station wages,
Building and macinery repairs,
Miscellaneous expenses.

This last item covers those items arising in the operation of a plant that can not readily be split up into other items, except by a great deal of detail.

These expenses are easily obtained from the companies' books, but there are other expenses, viz: mangement, superintendence, depreciation, sinking fund for retiring the bonded debt, interest, insurance and taxes. Dividends on capital stock are omitted, as it is assumed that the plant is constructed entirely with borrowed capital and therefore the stock has only a nominal or voting power value. The overhead and fixed charges can not be accurately determined, as the accounts include pipe lines, reservoirs, standpipes and other pumping stations, and therefore they have been merely estimated.

Management.

Under this heading we include the legal organization of the company, consisting of a president, a treasurer, who also acts as the secretary, and a board of three directors. The president and treasurer each receive $1,000 per year for their services, and the directors each receive $10 per board meeting. Assuming that the board meets once a month and are all present this charge would amount to $360 per year, or a total of $2,360 for mangement. This amount covers the entire system. The amount chargeable to mechanical plant is necessarily very small, but we have arbitrarily taken it at $200 per year for each company.

Superintendence.

Under this heading is included not only the salary of the superintendent, but that of his office assistance, stationery, postage, telegraph, telephone, office rent, livery and other incidental expenses. The superintendent must necessarily be a high grade man, for the success of the plant depends upon him.

The superintendent's salary we have placed at	$2,500	per year.
A bookkeeper and clerk at	1,200	" "
A stenographer at	500	" "
Office rent, including heat, light, water, etc.	300	" "
Postage	100	" "
Telephone and telegraph	170	" "
Stationery	250	" "
Livery and miscellaneous expenses	500	" "
Making a total of	$5,520	" "
Of which amount we have charged 16 1-3% to the mechanical plant, amounting to	$ 920	" "

Depreciation.

Here we have only to consider the mechanical plant and its housing. For the Corliss engine plant we have figured upon an average life of 20 years for the mechanical plant, and 35 years for buildings, etc. For the gas producer plant, we have allowed an average life of only 15 years for mechanical plant and 35 years for buildings. Our reason for allowing only 15 years for the gas engine plant is that we have not had sufficient experience with this class of machinery to warrant our giving it a longer life, although w can see no reason why its life should not equal that of a steam driven plant.

We therefore set aside at the end of each year a sum which at 4% compound interest will at the expiration of the life of the plant amount to its first cost,

This sum is

1st Delaware Plant.

For mechanical plant excluding filters	$ 1,236.00
For building	458.00
Total each year	$ 1,694.00

2nd Octoraro Plant.

For mechanical plant	1,340.00
For buildings	447.00
Total each year	$ 1,787.00

It will be noted that no depreciation is allowed for obsolescence, inadequacy or supersession.

Sinking Fund for Retiring Bonded Debt.

We are of the opinion that this item should not be included in the cost of operating a public utility, for the reason that capital should be everlasting; nevertheless, the courts of our country allow it, and, furthermore, we have seen, time and again, private water, gas and electric light companies' plants virtually confiscated by the public through the instrumentality of completing plants paralleling the lines and mains of the older company, so a sinking fund is imperative or no company could dispose of its bonds. This sinking fund we have figured upon a 4% basis, 30 year life of bonds—and amounts to $1,043.00 for the Delaware Company plant and $1,297.00 for the Octoraro plant.

Interest.

We will issue bonds having a rate of interest sufficient to cause them to sell at par. This interest we have taken at 7%, as this would seem to be about the rate of interest this class of investments should bear, where the plants are well established in a growing territory. This annual charge amounts to $4,095 for the Delaware plant and $6,491 for the Octoraro plant.

Insurance.

This item covers fire liability and boiler insurance. The buildings of both plants are substantially built of non-burning material, except for windows doors, and roof, and could therefore be but little damaged by fire. The machinery would however be subject to considerable damage. We have therefore, for insurance purposes, placed a valuation of $20,000 on the Delaware plant and $30,000 on the Octoraro or steam plant. Both plants are fully equipped with fire fighting apparatus and thereby receive the benefit of the lowest insurance rates for isolated plants. This amounts to $66 per year for the Delaware plant and $90 per year for the Octoraro

plant. The boiler and liability insurance we have taken at $160 per year for the Octoraro plant. The Delaware plant has no boiler plant and therefore only liability insurance is carried. This costs $10 per year for $10,000 insurance. We have, therefore, a total insurance charge of $76 for the Delaware plant and $250 for the Octoraro plant.

Taxes.

The state levies a bond tax of four-tenths of one per cent. on all bonds, and five-tenths of one per cent. on the value of the stock as assessed by the State. As before stated, the stock has only a nominal value of $10 per share, and for the purposes of taxation we will assume that the same amount of stock as bonds is issued. This would be the equivalent of a tax of 45-100 of one per cent. on the bond issue alone and would amout to

For the Delaware plant, $263.00 per annum.

For the Octoraro plant, $327.00 per annum.

Grouping the above items into a table we have thefollowing:

TABLE I.

Item.	*Delaware Plant.*	*Octoraro Plant.*
Management	$ 200.00	$ 200.00
Superintendence	920.00	920.00
Depreciation	1,694.00	1,987.00
Sinking Fund	1,043.00	1,297.00
Interest	4,095.00	6,491.00
Insurance	76.00	250.00
Taxes	263.00	327.00
or grand totals of	$8,291.00 per annum	
for the Delaware plant, and		$11,472.00
		for the Octoraro plant.

Operating Expenses.

Below is given a table of operating expenses of the two plants. For ease of comparison each year for both plants is placed in adjoining columns.

Table II.

Operating Charges.

Delaware Water Co., Gas Plant. Octoraro Water Co., Steam Plant.

ITEM.	1908		1909		1910		1911		1912	
	Plant		Plant		Plant		Plant		Plant	
	Gas.	Steam	Gas.	Steam	Gas.	Steam	Gas.	Steam	Gas.	Steam
Fuel	609.22	3497.78	641.51	3953.50	1173.58	4098.81	1474.40	4167.80	1796.35	4418.07
Oil, Waste and Packing	180.62	182.88	195.58	168.90	383.33	128.93	227.57	201.88	200.64	202.70
Building and Machinery Repairs	100.64	108.83	*280.07	14.00	†418.73	245.97	251.06	542.87	‡416.19	608.88
Pumping Station Wages	1501.67	2529.60	1853.06	2412.15	2276.03	2309.88	2518.27	2180.00	2507.89	2382.82
Miscellaneous Expenses	75.09	192.59	133.75	107.09	143.18	81.11	188.90	146.08	274.81	197.30
Total per Annum	2367.26	6506.18	3103.97	6655.64	4344.85	6864.80	4655.2	7238.81	5195.88	7804.72

*Includes the replacing of spiral riveted purge pipes on producers, with cast iron pipe.

†Includes spare parts for engines, such as inlet and exhaust valves, piston rings and piston, etc.

‡Includes compromise settlement of claim for damaged castings that developed in producer in 1908, before the plant was finally accepted.

Combining Tables I and II we obtain Table III, which gives the total combined operating and fixed charges for each of the plants:

Table III.

Combined Fixed and Operating Charges.

Delaware Water Co., Gas Plant. Octoraro Water Co., Steam Plant.

ITEM.	1908		1909		1910		1911		1912	
	Plant		Plant		Plant		Plant		Plant	
	Gas.	Steam	Gas.	Steam	Gas.	Steam	Gas.	Steam	Gas.	Steam
Operating Expenses	2367.26	6506.18	3103.97	6655.64	4344.85	6864.80	4655.20	7238.81	5195.88	7804.72
Fixed and Overhead Charges	8291.00	11472.00	8291.00	11472.00	8291.00	11472.00	8291.00	11472.00	8291.00	11472.00
Total Yearly Cost	10658.26	17978.18	11394.97	18127.64	12635.85	18710.81	12746.20	18710.81	13486.88	19276.72

Mechanical Performance of Plant.

We have tabulated the principal items of the daily log records of the plant for each month, showing the average results for each year and for the total period of five years. This record is shown in Table IV, and, as a further aid and to show the monthly variations in operation, we have plotted them as a diagram.

Table No. IV.

Summary of Pumping Station Daily Record Sheets

Delaware Water Company, Christiana, Del. Octoraro Water Company, Quarryville, Pa.

Unit.	Year.	Jan.		Feb.		Mar.		April.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.		Average for One Year.		Average for Five Years.		Year.
		Gas Plant.	Steam Plant.	Gas Plant.	Steam Plant.	Gas Plant.	Steam Plant.	Gas Plant.	Steam Plant.	Gas Plant.	Steam Plant.	Gas Plant.	Steam Plant.	Gas Plant.	Steam Plant.	Gas Plant.	Steam Plant.	Gas Plant.	Steam Plant.	Gas Plant.	Steam Plant.	Gas Plant.	Steam Plant.	Gas Plant.	Steam Plant.	Gas Plant.	Steam Plant.	Gas Plant.	Steam Plant.	
Average Daily Hours of Operation for One Engine.	1908	8.24	9.50	9.57	10.70	9.05	7.26	9.48	8.71	9.26	11.65	9.18	9.49	9.85	8.54	9.06	8.53	8.72	9.29	8.19	10.33	8.37	9.03	8.60	10.10	9.96	10.26	....	....	1908
	1909	8.44	8.22	9.10	5.98	9.44	5.32	8.63	6.78	8.56	4.23	9.02	6.38	8.80	10.01	8.69	10.80	22.10	12.03	23.20	12.61	21.35	13.16	23.80	15.85	13.43	9.28	....	....	1909
	1910	33.70	15.14	28.15	11.63	29.60	8.60	27.45	8.46	30.20	10.30	27.50	7.97	30.70	7.48	29.65	8.50	28.90	10.69	29.50	11.35	26.80	12.70	27.10	15.15	26.76	10.66	....	....	1910
	1911	32.80	13.90	26.20	11.18	38.55	9.89	30.20	7.92	32.90	11.22	29.80	10.91	25.55	12.80	29.90	12.90	39.30	10.06	31.30	10.46	25.85	10.61	35.00	9.88	30.61	10.98	....	....	1911
	1912	35.35	12.67	30.80	13.25	31.55	11.30	37.20	8.48	33.70	8.78	32.35	9.59	29.30	11.00	30.70	12.82	32.10	14.15	30.45	14.80	26.80	13.70	35.88	14.35	32.18	12.07	22.39	10.65	1912
Average Daily Coal Consumption in Tons of 2,240 lbs.	1908	.304	2.38	.326	2.58	.323	1.70	.305	2.05	.276	2.22	.313	2.22	.305	2.11	.304	2.12	.302	2.27	.268	2.68	.287	2.24	.263	2.58	.298	2.26	....	....	1908
	1909	.252	2.05	.315	1.58	.281	1.42	.268	1.78	.248	1.17	.277	1.65	.271	2.44	.279	2.66	.868	2.94	.883	3.05	.865	3.17	.881	3.45	.474	2.28	....	....	1909
	1910	.957	3.48	1.040	2.95	.945	2.22	.829	2.19	.861	2.53	.834	1.96	.931	1.81	.825	2.18	.849	2.63	.934	2.89	.869	3.15	.874	3.70	.896	2.64	....	....	1910
	1911	1.054	3.35	.770	2.78	1.168	2.48	.963	2.03	1.040	2.66	.990	2.63	.830	2.93	1.010	2.87	1.295	2.31	.930	2.49	.830	2.67	1.140	2.31	1.002	2.63	....	....	1911
	1912	1.240	3.01	1.100	3.05	1.091	2.73	1.288	2.07	1.080	2.28	1.046	2.32	.988	2.59	1.182	2.89	1.290	3.13	.995	3.29	.957	3.18	1.220	3.46	1.123	2.83	.758	2.53	1912
Average Daily Pumpage in Million Gallons Actual Conditions.	1908	.547	1.138	.623	1.292	.581	.794	.617	1.074	.579	1.081	.577	1.094	.579	1.066	.546	1.075	.523	1.172	.495	1.293	.509	1.081	.521	1.218	.550	1.115	....	....	1908
	1909	.519	.931	.556	.702	.571	.628	.516	.822	.517	.505	.560	.756	.543	1.344	.544	1.360	1.510	1.508	1.698	1.550	1.763	1.613	1.835	1.938	.928	1.138	....	....	1909
	1910	1.820	1.824	1.880	1.425	1.708	1.030	1.681	1.041	1.570	1.260	1.677	.934	1.826	.974	1.700	1.068	1.785	1.359	1.760	1.437	1.617	1.604	1.655	1.895	1.723	1.321	....	....	1910
	1911	1.994	1.720	1.530	1.355	2.360	1.197	1.816	.967	1.657	1.376	1.791	1.334	1.541	1.591	1.813	1.590	2.036	1.229	1.850	1.293	1.490	1.299	1.991	1.185	1.822	1.345	....	....	1911
	1912	2.081	1.540	1.825	1.600	1.550	1.370	2.204	1.027	1.973	.957	1.936	1.058	1.759	1.311	1.813	1.583	1.886	1.685	1.780	1.796	1.610	1.708	2.089	1.746	1.875	1.448	1.380	1.273	1912
Average Daily Pumpage in Million Gallons Reduced to 100-ft. Lift.	1908	.668	4.130	.728	4.630	.640	2.890	.715	3.485	.675	3.890	.684	3.960	.686	3.820	.630	3.800	.669	4.165	.550	4.610	.585	3.885	.640	4.350	.639	3.970	....	....	1908
	1909	.607	3.310	.649	2.530	.680	2.335	.603	2.035	.598	1.920	.643	2.780	.625	4.780	.606	4.920	2.398	5.290	2.535	5.360	2.448	5.880	2.245	7.125	1.220	4.022	....	....	1909
	1910	2.684	6.740	2.619	5.205	2.441	3.875	2.362	3.923	2.430	4.600	2.423	3.400	2.668	3.520	2.409	3.410	2.554	4.450	2.519	4.750	2.317	5.320	2.440	6.320	2.489	4.624	....	....	1910
	1911	2.865	5.850	2.216	4.650	3.630	4.150	2.643	3.350	2.914	4.770	2.544	4.560	2.154	5.340	2.736	5.345	3.003	3.290	2.667	4.450	1.986	4.640	2.880	4.330	2.686	4.560	....	....	1911
	1912	2.954	5.600	2.455	5.860	2.512	5.040	3.129	3.780	2.713	3.815	2.668	4.190	2.400	4.660	2.780	5.590	2.734	6.020	2.395	6.220	2.119	6.000	2.926	6.320	2.649	5.258	1.940	4.487	1912
Average Daily Duty per 100 lbs. Coal Based on Water Actually Delivered Into Reservoir.	1908	81.7	65.5	83.1	67.0	73.7	63.2	87.3	63.4	91.0	65.2	81.3	66.4	83.7	67.4	77.1	66.9	81.1	68.2	76.4	64.0	75.8	64.4	90.5	62.8	79.7	65.4	....	....	1908
	1909	89.6	60.1	76.6	59.5	90.1	61.1	83.7	62.5	89.7	61.0	86.5	62.6	85.8	72.9	80.8	68.7	102.8	67.1	106.8	65.4	105.4	69.0	94.7	76.8	95.8	65.5	....	....	1909
	1910	104.5	72.0	93.6	65.6	96.2	64.9	106.2	66.6	105.0	67.8	108.2	64.7	106.7	72.4	108.8	58.2	111.9	63.0	100.4	61.1	99.4	62.7	104.0	63.6	103.4	65.2	....	....	1910
	1911	101.1	65.0	107.9	62.2	115.8	62.2	102.2	61.5	104.2	66.6	95.7	64.6	96.5	67.9	100.5	69.3	86.4	53.0	106.8	66.5	89.1	64.7	94.0	69.9	99.8	64.6	....	....	1911
	1912	88.6	69.3	83.0	71.5	85.6	68.9	90.4	68.0	93.4	62.3	95.0	67.3	90.4	67.0	87.5	72.0	78.7	71.5	89.6	70.4	82.4	70.3	88.2	68.0	87.6	69.1	95.2	65.9	1912
Pounds of Coal per H. P. Hour Based on Water Actually Delivered Into Reservoir.	1908	2.434	3.020	2.384	2.960	2.685	3.135	2.208	3.126	2.175	3.040	2.439	2.988	2.366	2.940	2.566	2.986	2.440	2.906	2.593	3.094	2.612	3.075	2.187	3.152	2.49	3.03	....	....	1908
	1909	2.208	3.292	2.583	3.330	2.195	3.238	2.366	3.169	2.210	3.244	2.290	3.160	2.308	2.720	2.452	2.890	1.920	2.950	1.854	3.030	1.881	2.872	2.092	2.576	2.07	3.03	....	....	1909
	1910	1.895	2.750	2.116	3.016	2.060	3.052	1.863	2.972	1.886	2.920	1.833	3.058	1.857	2.738	1.821	3.400	1.772	3.145	1.971	3.240	1.993	3.157	1.906	3.110	1.91	3.04	....	....	1910
	1911	1.958	3.045	1.852	3.190	1.710	3.190	1.937	3.230	1.900	2.972	2.070	3.065	2.052	2.920	1.970	2.860	2.292	3.735	1.855	2.980	2.221	3.062	2.106	2.835	1.985	3.07	....	....	1911
	1912	2.235	2.856	2.386	2.770	2.312	2.875	2.190	2.920	2.120	3.180	2.086	2.943	2.190	2.958	2.262	2.762	2.515	2.770	2.208	2.812	2.400	2.814	2.247	3.134	2.26	2.86	2.08	3.01	1912

Economical Results.

From the information obtained and shown in Tables I, II and III, we have prepared Table V, which gives the cost of pumping one million gallons of water, one hundred feet high.

TABLE V.

COST OF PUMPING ONE MILLION GALLONS 100 FT. HIGH.

OVERHEAD, FIXED AND OPERATING CHARGES.

Delaware Water Co's., Gas Engine Plant. Octoraro Water Co's., Steam Engine Plant.

UNIT PER MILLION GALLONS ACTUALLY PUMPED 100 FT. HIGH		1908		1909		1910		1911		1912	
		Gas.	Steam	Gas.	Steam	Gas.	Steam	Gas.	Steam	Gas.	Steam
Management	1	0.995	0.491	.589	.482	.318	.415	.301	.407	.293	.376
Superintendence	2	4.590	2.265	2.715	2.215	1.465	1.908	1.381	1.875	1.345	1.741
Depreciation	3	8.440	4.985	5.000	4.790	2.695	4.120	2.552	4.050	2.480	3.755
Sinking Fund	4	5.200	3.180	3.080	3.120	1.658	2.685	1.569	2.645	1.522	2.498
Interest	5	20.400	15.970	12.080	15.620	6.500	13.440	6.150	13.230	5.980	12.270
Insurance	6	.379	.615	.224	.602	.121	.519	.114	.509	.111	.473
Taxes	7	1.313	.803	.787	.788	.418	.693	.396	.666	.400	.618
Total Cost Per Annum	8	41.317	28.219	24.475	27.617	13.175	23.780	12.463	23.382	12.131	21.731
Fuel	9	2.615	2.410	1.441	2.698	1.291	2.425	1.505	2.510	1.860	2.305
Oil, Waste and Packing	10	0.775	.126	.439	.115	.366	.076	.232	.126	.208	.106
Pumping Station Wages	11	7.490	6.210	5.470	5.825	3.615	4.790	3.787	4.450	3.670	4.520
Machinery Repairs and Building	12	.432	.072	.631	.0095	.461	.146	.256	.327	.431	.315
Miscellaneous Expenses	13	.322	.133	.300	.0735	.157	.048	.188	.088	.285	.103
Total Cost Per Annum	14	11.634	8.951	8.281	8.721	5.890	7.485	5.968	7.501	6.454	7.349
Total of Operating and Fixed Charges	15	52.951	37.170	32.756	36.338	19.065	31.265	18.431	30.883	18.585	29.080
	16	Average cost of pumping 1 million gals. 100 ft. high—Gas, 28.36									
	17	Average cost of pumping 1 million gals. 100 ft. high—steam, 32.95									
	18										

This we have divided up to show the cost per million gallons for each of the items that ordinarily go to make up the cost of pumping water. Line 8 shows the total for fixed and overhead charges, while Line 14 covers the total cost for operating charges, and, finally, Line 15 gives the combined total cost.

The cost per million gallons for items, Lines 1 to 7 inclusive of fixed charges, and Line 11 of operating charges, was obtained by dividing the annual cost for that item by the actual number of million gallons pumped for the year, as these charges were independent of the pumping head. Items 9, 10, 12 and 13 were obtained by dividing the annual cost by the equivalent million gallons pumped one hundred feet high for year.

Lines 16 and 17 show the average cost per million gallons for the five year period, $28.36 for the gas plant and $32.95 for the steam plant.

This is equivalent to $56.80 and $68.50 per horsepower for 24 hour power delivered to the customer, or, stated another way, it is equivalent to .88 and 1.05 cents per kilowatt for the steam and gas plants respectively.

In conclusion it may be stated that the figures given are the actual results obtained in two existing plants similarly situated and therefore comparable.

Necessarily, the local conditions, nature and cost of fuel available, etc., must enter into every discussion as to the kind of power to be adopted for a proposed plant, but it is our opinion that the gas engine driven pumping engine has a much wider field than has heretofore been accorded it.

We wish to thank those who in their official capacity have permitted the use of the data that has made this paper possible.

DISCUSSION.

MR. LEDOUX.—It will be noted that the steam plant referred to by Mr. Gibson ran on the average about half of the 24 hours, while the gas plant generally ran the entire 24 hours. The comparison in favor of the gas plant may be assumed by many as due to this fact. However, the average duty of that particular steam plant amounted to about 66,000,000, which is about as high as is obtained in other similar plants where the run is continuous. This high duty is evidently due to the good fuel, good management and excellent handling of the plant. About 70,000,000 annual duty is in my judgment the upper limit of a plant of that kind.

PROF. FERNALD.—I am not prepared to discuss the paper in detail, but I am very much interested in the statements of fuel efficiency and the operation of the plants. I have been following producer gas problems for some time, and have been pleased to see how the problem has worked out in favor of the gas plant under actual operating conditions.

There is one feature, however, I would like to call attention to. In this particular installation we find very high grade coal being used. In a plant that is operating under rather ideal conditions for producer gas work, that is, under uniform load, the producer gas plant makes good. What those of us who are interested in producer gas would like to see is the utilization of grades of fuel that can not be used to good advantage in steam plants. Not only have producer gas planst made good on high grades fuels, but it has been demonstrated that low grade fuels can be utilized to good advantage. I hope this organization may have reports of plants which have been operating on grades of fuel that are not advantageous in ordinary steam plants, because that is a field of great importance as far as our fuel conservation is concerned, and the time is coming when we will

have to use grades of fuel that are not now commercially valuable I would like to know whether any attempts have been made in the plant under discussion to use such grades of fuel.

DR. CHANCE.—I like very much to see the gas engine shown up in as favorable a way as possible as compared with steam plants, but I do not exactly understand the basis on which it is fair to compare the cost of a relatively small plant with a relatively much larger plant. I do not understand either how it is fair to steam plants to compare a plant which is running on a relatively low load factor, with a gas plant that runs on a much higher factor, and I would ask whether any corrections were introduced to balance this diffierence.

MR. GIBSON.—The figures given in the paper are those actually obtained at the two plants under normal operating conditions. It will be noted that for about 12 of the 24 hours, two gas engines were run, and for the purpose of supplying gas, two producers were run. However, when the second gas engine was shut down, one producer was shut down at the same time, so that during this interval of time there is a standby loss on one of the producers, which is charged up to the operation of the entire plant. The standby losses of the steam plant are, of course, higher than those of the gas plant, as it runs only a portion of the day, but this in turn is offset to quite an extent by the steam engine plant having a much larger capacity and higher head to pump against. The actual cost of the two plants is about the same, but had the gas plant been installed of equal capacity with the steam plant, its cost would probably have exceeded the steam plant a little bit, although in some recent figures which I have made, I find that a gas plant installation does not exceed that of a steam plant installation of the same size.

Answering Professor Fernald, I would state that no effort has been made to burn cheap fuel in either of these plants, as we find it pays to buy the best coal obtainable in the market. With the best fuel we obtain not only the highest economy in operation but the greatest amount of satisfaction in our employees, and, as a metallurgical engineer recently said, "The labor is very often more refractory than the material," we count the satisfaction of our employees as a very desirable factor in the operation of our water works plants.

MR. CODMAN.—What is the value of that gas in cubic feet?

MR. GIBSON.—It will probably have heat value in the neighborhood of 125 B. T. U. per cubic foot.

MR. CODMAN.—Natural gas in Pittsburgh tested at 900 B. T. U., the gas we have here in the City is partly producer gas and partly enriched gas; it has by .U. G. I. tests 675 B. T. U.

MR. W. T. PRICE.—In regard to the amount of attention required. How many men are needed at the plant for the day time and how many at night for operating the engines?

MR. GIBSON.—There is a chief engineer and two assistant engineers. The Chief Engineer lives in the Company's house nearby and is subject to call 24 hours per day. The assistant engineers work alternate shifts, one being on duty at the same time the Chief Engineer is, and the other, or night shift, being alone.

The Chief Engineer with the asistance of the assistant engineer on day shift is supposed to look after the up-keep and repairs to the plant and keep all records of the operation of the plant.

MR. PRICE.—Mr. Gibson's paper is very broad in its field, giving figures for total cost, whereas we so often get figures dealing only with fuel and operating costs.

One of our members spoke about the utilization of low grade coal for producer gas work. I think it has been the experience of all those around Philadelphia who have producer gas work in charge, that it is not only advisable but really necessary to use a high grade fuel in order to get dependable operation.

Something of interest I noticed in Mr. Gibson's paper, is that while the fuel consumption under test showed 1.25 pounds of coal per Water H. P. hour, the actual result for a period of five years was 2.08 pounds, 81% in excess. I think it is always the case with producer gas equipment that the pounds of coal per H. P. hour when taken over a long period of operation run considerably higher than that shown by a test.

For five years I have been connected with a company (the De La Vergne Machine Company) building both gas engines and another type of internal combustion engine and we have found in the past four or five years that the oil engine, for a great many cases, has the preference among most power users. We have had better results through the use of oil engines than with gas engines. During the past year, however, the price of oil has increased considerably. The oil coming from the Pennsylvania fields, the Mid-continent and the Texas fields so increased in price that the oil engine was not as economical as before, and the fuel cost was raised above that of producer gas equipment. At the present time, however, Mexican oil is coming in. It can be purchased around Philadelphia for 3.7 cents per gallon, whereas the other oils sell around 5 cents. Figuring on oil at 4 cents per gallon instead of 3.7, thus allowing for the difference in freight rate between here and this Delaware pumping plant, and also allowing for the work of hauling to the plant, the cost per Water H. P. hour would be considerably less with oil engines than with producer gas. Assuming 75% pumping efficiency, which Mr. Gibson's figures indicate, the cost for the oil engine would be $.00334 per Water H. P. hour, and for the gas engine $.00475. In this case the fuel cost is 42% higher with gas than it would be with oil, and this would represent a difference of about $600 per year. I have no figures showing the fuel consumption of an oil engine driven water pumping plant over a period of years, but I have some figures on a slide showing the total fuel consumption for two years with a 180 H. P. engine operating at an average load of something over 52%. It has been our experience with all oil engine installations that the fuel consumption per B. H. P. hour for a term of years is practically identical to the fuel consumption per B. H. P. hour under test, whereas with producer gas equipment there s always a wide discrepancy.

MR. WOOD.—The case of the producer gas engine or oil engine vs. the steam engine or steam turbine may, I think, be summed up in the statement that the producer gas engine and oil engine have their fields in small powers, and loads of certain character, and that these forms of prime movers cannot successfully compete against the steam engine or steam turbine in plants where a large amount

of power is developed or where the exhaust steam can be utilized for heating. In the latter case the gas engine or oil engine has no field, even for small powers. In the case of plants where only power is required, and where the amount of power developed is less than 200 or 300 H. P., the producer gas engine or oil engine undoubtedly will show a decided economy over the steam engine, particularly if the water supply of the plant is so limited as to preclude the operation of the engine or turbine under vacuum.

DR. CHANCE.—I do not think the discussion should be closed with a statement so broad as that, that the gas engine is not in it with the steam for powers exceeding 200 H. P.

MR. WOOD.—The principal point of my argument for the steam engine is based on the fact that a steam plant of large size can be built for one-half to one-third the cost of a gas or oil engine plant, and that the saving in capital charges and repairs in a steam plant will out-weigh the saving in fuel in the case of a gas or oil engine plant. As a matter of fact in large steam plants, properly designed and operated, the coal consumption per unit of power is just as good as can be obtained in any producer gas engine plant, while the total cost of producing power (capital charges included) is much lower.

MR. PRICE.—The Mesta Machine Company are prepared to delivery anything at $92 per K. W. If you figure it against a steam turbine plant at $85 to $90 per K. W. it does not look so bad, and you do not have the trouble of keeping up boilers.

MR. WOOD.—In reply to Mr. Price's remark, I would say that my opinion is that any large power installations that cost $80 to $90 per K. W., including buildings and equipment of every kind, will have a hard time making a living in the very near future. In order to meet the market for cheap power, the cost of large central stations must be gotten down to something more like $50 per K. W.

MR. LEDOUX.—I do not think this discussion is exactly scientific. Mr. Wood's statement does not impress me, but until I know the cost of 15 or 10,000 H. P. gas plants and the cost of operation, I am "from Missouri" as compared with steam engines or any other kind.

MR. WOOD.—The total cost of the plant referred to, including buildings and all equipment, was approximately $41.50 per K. W. if installed capacity.

MR. GIBSON.—What size plant was this?

MR. WOOD.—I think in the neighborhood of 45,000 K. W. I happen to know of some recent estimates for a large Railway Station where the Engineers figure that the cost of the plant will not exceed $40 per K. W., and appropriations for the work will be made on this basis.

Mr. Price put a slide on the screen showing the following operating costs:

OPERATING COST OF DE LA VERGNE TYPE "FH" OIL ENGINES.

The following is a tabulation of reports received from the Snead & Company Iron Works, Jersey City, N. J., giving the cost of power at their plant for twenty-four months, ending February 1st, 1912.

The plant consists of one 17 x 27½ De La Vergne type "FH" twin cylinder oil engine—180 brake horsepower rated capacity, direct connected to a 125 K. W. 525 volt D. C. generator; the electric current generated being utilized to drive motors and for lighting purposes.

ACTUAL COST OF POWER.

Plant operated 588 days or 5985.30 hours total:
Total K. W. hours produced 369,684—552,217 brake horsepower hours by calculation.
Load Factor—54.2%

	Total	Per K. W. Hr.	Per B. H. P. Hr.
Fuel Oil 38,211 gallons	$859.75	$.00232	$.00155
Lubrication	228.72	.00061	.00041
Miscellaneous	123.20	.00032	.00022
Labor and attendance	1361.42	.00368	.00246
	$2573.09	$.00693	$.00464

Fuel oil employed 28.8° Beaume = 7.35 pounds per gallon.
Pounds of oil used—.761 per K.W. hour—*.508 per horsepower hour.*

The point I wish to bring out is this:

This 180 HP. type "F. H." De La Vergne oil engine was guaranteed to develop its power at the following load of fuel consumption:

Full load	0.5	pound	per B. H. P. Hr.	
¾	" 0.5	"	"	"
½	" 0.55	"	"	"

The engine operated at an average load of 54.2% for a period of two years and during that time the total oil consumption was 38,211 gallons which is at the rate of 0.508 pounds per brake horsepower hour. It is true in the general case that the operating results with an oil engine are identical with the test results.

The next slide shows a longitudinal section of a De La Vergne type "FH" engine, which is the type adapted to burn Mexican crude oil and tars. The difference between this engine and the Diesel type is that the compression pressure is carried only to 280 pounds instead of 525 and at the end of the compression stroke the oil is atomized by compressed air into the vaporizer chamber shown by the circle at "D". In order to work with the greatest economy it is necessary

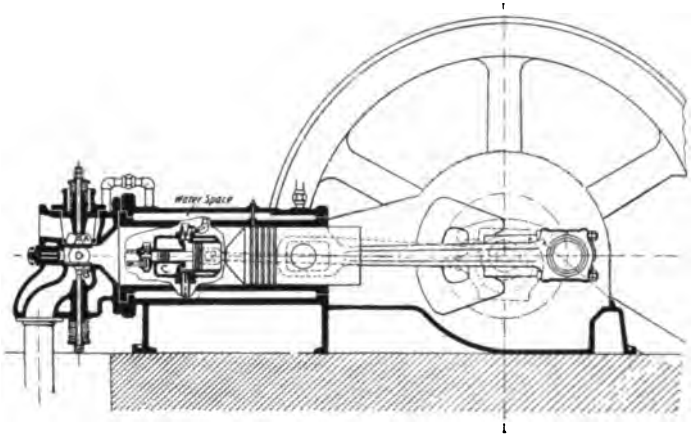


FIG. 2.
Longitudinal Section of Engine.

to burn the cheap Mexican crude oils, and to do this the vaporizer chamber must be used. It is not necessary to treat this vaporizer with the same degree of respect as one would the cylinder walls in the case of the Diesel type of engine, where the oil is injected directly into the cylinder. We have had no trouble whatever in burning not only Mexican crude oil, but also water gas tar and coke oven tar without carbonization of any kind.

W. J. WARNER

Mr. Walter J. Warner, Associate Member of the Engineers' Club, formerly connected with W. S. P. Shields, died suddenly on June 10th, 1913.

R. A. SHILLINGFORD.

Mr. Shillingford was born in Philadelphia in 1857; a graduate of the University of Pennsylvania in 1879 and afterwards connected with the Cambria Steel Company of Johnstown, Pa., and later with the Berwind White Coal Mining Company as Mine Engineer. In 1887 he became Superintendent of the Clearfield Bituminous Coal Corporation at Peale, Pa., and in 1900 removed to Clearfield, Pa. In 1909 he was made Vice President and General Manager of the Clearfield Bituminous Coal Corporation. At the time of his death he also held the position as Inspector of coal properties of the N. Y. C. & H. R. R. R. He was Director of the Beech Creek Railroad, and of the Clearfield & Franklin R. R. He was also a Director of the Clearfield Trust Company, and later was Vice President of that institution, and at the time of his death was President. He was Vice President of the Clymer Electric Company, and Director of the State Central Electric Company. He was a Director of the Kittanning Coal Company of Philadelphia, Empire Coal Mining Company of Philadelphia and Pioneer Coal Company of Philadelphia. In 1908, he was a member of the Commission appointed by the Governor of Pennsylvania, to revise the mining laws of this state. He was a member of the University Club of Philadelphia, Engineers' Club of Philadelphia and Pennsylvania Society of New York.

Mr. Shillingford died Monday, June 16, 1913.

PAPERS SCHEDULED FOR THE FALL TERM

The Meetings Committee beg to announce that the following papers have been scheduled for the fall term:

September 20—SEWAGE TREATMENT IN PENNSYLVANIA.
By Charles F. Mebus, Vice President, Engineers' Club.

October 4—THE LIMITATIONS OF MATHEMATICAL THEORY APPLIED TO ENGINEERING.
By W. G. Button, Engineer, Bureau of Building Inspection, Philadelphia.

October 18—MODERN COLOR PHOTOGRAPHY.
By Henry Leffmann, Past President, Engineers' Club.

November 1—HOUSING AND SANITATION.
By Bernard J. Newman, Secy., Phila. Housing Commission.

November 15—THE GRAND CENTRAL TERMINAL IMPROVEMENTS.
By George A. Harwood, Chief Engineer, N. Y. C. & H. R. Railroad.

December 6—THE HUDSON RIVER SIPHON.
By Ralph N. Wheeler, Division Engineer, Board of Water Supply, New York.

December 20—CONCRETE ROADWAYS.
By Lewis R. Ferguson, Asst. Secy., Amer. Portland Cement Manufacturers.

January 3—THE SCRANTON MINE PROBLEM.
By Eli T. Conner, Consulting Mining Engineer.

January 17—SOME RECENT IMPROVEMENTS IN STEAM LOCOMOTIVES.
By George R. Henderson, Consulting Engineer, Baldwin Locomotive Works.

February 7—ANNUAL MEETING.—Presidential Address.

ADDITIONS TO THE LIBRARY

The following books have been presented to the library of the Engineers' Club by the Junior Section:—

Technological Dictionary (3 vols.)—*Tolhausen.*
Municipal Franchises—*Wilcox.*
Engineering Valuation of Public Utilities—*Foster.*
The Law of Operation—*Wait.*
Valuation of Public Service Corporations—*Whitten.*
Logarithms—*Bruhns.*
Advanced Algebra—*Milne.*
Plane and Solid Geometry—*Milne.*
Evolution of Internal Combustion Engines—*Butler.*
Applied Mechanics—*Rankin.*
Treatise on Hydraulics—*Merriman.*
Fire Prevention and Fire Protection—*Freitag.*
Principles of Concrete Construction—*Turneaure and Maurer.*
Field Engineering—*Searles.*
Cost Data—*Gillette.*
Engineering Work in Towns and Cities—*McCullough.*
Tunneling—*Prelini.*
Plane Surveying—*Tracy.*
Mechanics Applied to Engineering—*Goodman.*
Theory of Structures—*Spofford.*
American Civil Engineers' Pocketbook.
Engineering Index Annual—1912.
Principles of Electrical Engineering—*Pender.*
Electric Power Transmission—*Bell.*
The Art of Illumination—*Bell.*
Centrifugal Pumping Machinery—*De Laval.*
Mill Buildings—*Ketchum.*
Street Paving and Paving Material—*Tillson.*
American Highway Assoc. Good Roads Year Book—1913.
Freight Terminals and Trains—*Droege.*
Treatise on Roads and Pavements—*Baker.*
Dust Preventives and Road Binders—*Hubbard.*
Art of Roadmaking—*Frost.*
Modern Asphalt Pavements—*Richardson.*
Construction of Dams—*Wegmann.*
Reservoirs—*Schuyler.*
Central Station Heating—*Gifford.*
Practical Manual of Steam and Hot Water Heating—*Pierce.*

Sewage Disposal—*Fuller.*
Public Water Supplies—*Turneaure and Russell.*
Sewer Construction—*Ogden.*
Sewerage—*Fowell.*
Water Power—*Frizell.*
Journal Royal Institution of British Architects—1910.
Town Planning in Practice—*Unwin.*
Concrete and Steel Construction—*Morsch.*
Principles of Wireless Telegraphy—*Pierce.*
Chemiker Kalendar.
Explosives—*Brunswig.*
Portland Cement—*Butler.*
Corrosisn and Preservation of Iron and Steel—*Cushman and Gardner.*
Concrete Costs—*Taylor and Thompson.*
Walls, Bins and Grain Elevators—*Ketchum.*
Concrete, Plain and Reinforced—*Taylor and Thompson.*
Masonry Construction—*Baker.*
Architectural Engineering—*Freitag.*
Commercial and Library Atlas of the World—*Hammond.*
Paints and Varnishes—*Sabin.*

SOME LOCAL TRANSPORTATION STATISTICS

Miles of Track in Philadelphia.

Pennsylvania R. R.	502.2
B. & O.	70.0
Phila. & Reading Railway	*132.76
Phila. Rapid Transit Company	660.0

Passenger Trains per Day

	Inbound	Outbound
Pennsylvania R. R.	†580	†580
B. & O.	21	21
Phila. & Reading Railway.	229	234

Freight Trains and Tonnage

	Inbound		Outbound	
	Cars	*Tons*	*Cars*	*Tons*
Pennsylvania R. R.	658	11,514	749	10,526
B. & O.	‡15	11,000	‡12	6,000
Phila. & Reading Railway	‡79	§56,000	‡81	

The Philadelphia Rapid Transit Company operate approximately 2000 surface and 165 elevated cars.

*There are in addition 215.81 miles of sidings in the city of Philadelphia.

†This is the daily average and does not include 45 trains passing through West Philadelphia which do not enter Broad Street Station.

‡Trains.

§Includes anthracite and bituminous coal.

ABSTRACT OF MINUTES OF THE CLUB

BUSINESS MEETING, June 7, 1913.—The meeting was called to order by President Taylor at 8:35 P. M., with 57 members and visitors in attendance.

The minutes of the meeting of May 17th, 1913 were approved as printed in abstract.

Following the report of the Tellers, the President declared that the amendments submitted to the Club were carried and would be incorporated in the By-Laws.

The Committee on Nominations, consisting of H. E. Ehlers, Chairman, Joseph C. Wagner, F. H. Stier, Carl Hering, E. M. Nichols, Thomas C. McBride and George T. Gwilliam, appointed by the Board of Governors at their meeting of May 15th, was accepted.

Mr. D. Robert Yarnall presented the paper of the evening, entitled, "Scientific Management Applied to the Design and Management of a Modern Valve Plant," which was discussed by Messrs. John C. Trautwine, Jr., E. M. Nichols and J. E. Gibson.

ABSTRACT OF MINUTES OF THE BOARD OF GOVERNORS

SPECIAL MEETING, June 19, 1913.—The meeting was called to order at 8:10 P. M. Present, President Taylor, Vice Presidents Plack and Swaab, Directors Vogleson, Haldeman, Gibson, Worley, the Secretary and the Treasurer.

The Treasurer reported a net gain of $1929.19, as compared with $27.14 for the same period of last year.

The Treasurer was instructed to strike the names of William G. Bickell and F. K. Wilkinson from the roll as of July 1, 1913, for nonpayment of dues, and to charge off their dues from the books.

Reports of the Finance and House Committees were read and approved.

The report of the Membership Committee was read, and, in accordance with the recommendations of the Committee, the following were elected:

Active: William C. Greany, Crosby Miller. Associate: A. Morris Herkness, James F. McCrudden.

The death of Walter J. Warner was announced, and the Treasurer instructed to charge his dues off the books.

The question of rearranging the accounts and the appropriation schedule was referred to the Treasurer and Chairman of the Finance Committee, with power to act.

The President and Treasurer were authorized to enter into an agreement with the Business Manager, in which the payment of the bonus due the Business Manager be deferred until the annual audit of the books.

The report of the Business Manager was read and approved.

INDEX VOLUME XXX

ABSTRACT of Minutes of the Board of Governors 96, 202, 318, 400
of the Club 94, 200, 320, 399
Address of the President, Henry Hess 99
Allyn, Dr. Herman B., Discussion of Smoke Abaemtent 23
Anders, Dr., Discussion of Smoke Abatement 25
Annual Report of the Board of Governors 192

Ballinger, Walter F., Discussion of the Engineer's Interest in Public Land Questions 247
Bliss, George S., The Importance of Meteorological Data in Engineering 110
Burns, Frank, Obituary 189

Chance, Dr. H. M., Discussion of The Engineer's Interest in Public Land Questions 249
Discussion of The Sinking and Lining of Shafts 355
Chester, Rear Admiral C. M., The Panama Canal as it Relates to the Treaties 308
Cheyney, George S., Discussion of The Importance of Meteorological Data in Engineering 119
Codman, John E., The High Pressure Fire Service 325
Discussion of The High Pressure Fire Service 337
Discussion of The Importance of Meteorological
Conard, W. R., Data in Engineering 114
Discussion of the High Pressure Fire Service... 339
Conner, Eli T., Discussion of The Sinking and Lining of Shafts 354

Dallett, W. P., Discussion of The Importance of Meteorological Data in Engineering 120
Darrach, Charles G., Discussion of The High Pressure Fire Service 337
Donaldson, Francis, The Sinking and Lining of Shafts 341
Discussion of 354
Dunlap, E. E., Obituary 190

ENGINEER'S Interest in Public Land Questions, The, by Dr. George Otis Smith 239

Fernald, Prof. Robert H., Discussion of Smoke Abatement 27
Discussion of The Design and Construction of the Hydro-Electric Plant at Estacada, Oregon 388

Fritz, John, Obituary 188
Furber, W. C., Discussion of The Planning of City Streets 168
Discussion of The Sinking and Lining of Shafts 357

Gibson, J. E., Suction Gas Producer Pumping Engine vs. Compound Condensing Corliss Crank and Fly Wheel Pumping Engine 371
Discussion of, ... 389
Discussion of The Design and Construction of the Hydro-electric Plant at Estacada, Oregon .....
Haldeman, B. A. The Planning of City Streets 143
Hess, Henry, Stereophoto Surveying 121
Discussion of The Planning of City Streets 169
Hibbs, Manton E., The Unwritten Law 259
High Pressure Fire Service, The, by John E. Codman 325
Hydro-Electric Plant at Estacada, Oregon, The Design and Construction of the, by Hermann V. Schreiber 359

Irish, W. M., Discussion of The Manufacture of Petroleum Products 186

Knowles, Morris, Wise Utilization of Water Resources in Pennsylvania 207
Krauss, Edward E., Discussion of The Sinking and Lining of Shafts 357
Kuhn, Lt. Col. J. E., Some Aspects of the Subject of Transportation .. 281

Ledoux, J. W., Discussion of Suction Gas Producer Pumping Engine vs. Compound Condensing Corliss Crank and Fly Wheel Pumping Engine 388
Leffmann, Dr. Henry, Discussion of The Importance of Meteorogical Data in Engineering 116
Library, Additions to 396
Lukens, Mr., Discussions of Smoke Abatement 29

Maignen, P. A., Discussion of Sanitary Protection of the Water Supplies taken from the Great Lakes 90
Meteorological Data in Engineering, The Importance of, by George S. Bliss 110
McBride, O. R., Methods and Means of Smoke Abatement 1
Morris, Henry G., Discussion of Smoke Abatement 27
Discussion of The High Pressure Fire Service 338

Nichols, E. M., Discussion of The Planning of City Streets 171
Discussion of The High Pressure Fire Service 338

OBITUARIES, Frank Burns 189
E. E. Dunlap 190
John Fritz 188
R. A. Shillingford 394
W. J. Warner 394

PANAMA Canal as it Relates to the Treaties, by Rear Admiral C. M. Chester 308
Papers Scheduled for the Spring Term 191
Papers Scheduled for the Fall Term 395
Perkins, George H., The International Smoke Abatement Exhibition 12
Petroleum Products, The Manufacture of, by F. C. Robinson 172
Philadelphia, Some Interesting Facts about 323
Planning of City Streets, by B. A. Haldeman 143
Presidential Address 99
Price, William T., Discussion of The Manufacture of Petroleum Products 186
Discussion of The Design and Construction of the Hydro-Electric Plant at Estacada, Oregon 389

Quimby, H. H., Discussion of The Importance of Meteorological Data in Engineering 116
Discussion of The Planning of City Streets 167

Robinson, F. C., The Manufacture of Petroleum Products 172

SANITARY Protection of the Water Supplies taken from the Great Lakes, by George C. Whipple 53
Schreiber, Hermann V., The Design and Construction of the Hydro-Electric Plant at Estacada, Oregon 359
Shillingford, R. A., Obituary 394
Sinking and Lining of Shafts, The, by Francis Donaldson 341
Smith, Dr. George Otis, The Engineer's Interest in Public Land Questions 239
Smoke Abatement, Methods and Means of, by O. R. McBride 1
Smoke Abatement Exhibition, The International, by George H. Perkins 12
Stereophoto Surveying, by Henry Hess 121
Suction Gas Producer Pumping Engine vs. Compound Condensing Corliss Crank and Fly Wheel Pumping Engine, by J. E. Gibson 371
Swaab, S. M., Discussion of Sanitary Protection of Water Supplies taken from the Great Lakes 91
Discussion of The Planning of City Streets 165
Discussion of The High Pressure Fire Service 340
Discussion of The Sinking and Lining of Shafts 354

TRANSPORTATION, Some Aspects of the Subject of, by Lt. Col. J. E. Kuhn 281
Transportation Statistics, Some Local 399
Trautwine, John C. Jr. Discussion of the Importance of Meteorological Data in Engineering 114
Discussion of Wise Utilization of Water Resources in Pennsylvania 236
Discussion of The High Pressure Fire Service 337

UNIT Structural Concrete, The Development of, by C. D. Watson 31
Unwritten Law, The, by Manton E. Hibbs 256

Vogleson, J. A., Discussion of Sanitary Protection of Water Supplies taken from the Great Lakes 93

Warner, W. J., Obituary 394
Water Resources in Pennsylvania, Wise Utilization of, by Morris Knowles 207
Watson, C. D., The Development of Unit Structural Concrete 31
Webster, George S., Discussion of The Planning of City Streets 166
Whipple, George C., Sanitary Protection of the Water Supplies taken from the Great Lakes 53
Discussion of Sanitary Protection of the Water Supplies taken from the Great Lakes 91
Wood, A. C., Discussion of Suction Gas Producer Pumping Engine vs. Compound Condensing Corliss Crank and Fly Wheel Pumping Engine 390

THE ENGINEERS' CLUB OF PHILADELPHIA

1317 Spruce Street

OFFICERS FOR 1913

President
W. PURVES TAYLOR

Vice-Presidents

Term Expires 1913
W. L. PLACK

Term Expires 1914
CHARLES F. MEBUS

Term Expires 1915
S. M. SWAAB

Secretary
EDW. E. KRAUSS

Treasurer
J. REESE BAILEY

Directors

Term Expires 1914	*Term Expires 1915*	*Term Expires 1916*
R. G. DEVELIN	H. C. BERRY	J. E. GIBSON
RICHARD GILPIN	B. A. HALDEMAN	H. CLYDE SNOOK
J. A. VOGLESON	S. M. SWAAB	MORTON E. HIBBS
HENRY HESS	D. ROBERT YARNALL	J. FRANK WORLEY

Trustees of the Bond Redemption Fund
HENRY LEFFMANN, Chairman EDGAR MARBURG EDWIN F. SMITH

STANDING COMMITTEES

House—F. K. WORLEY, W. L. PLACK, J. A. VOGLESON, G. F. PAWLING, H. A. MOORE.

Meetings—S. M. SWAAB, B. A. HALDEMAN, D. R. YARNALL, J. B. MCCORD, W. C. FURBER.

Membership—CHAS. F. MEBUS, R. G. DEVELIN, H. C. SNOOK, H. H. QUIMBY, W. P. DALLETT.

Finance—J. A. VOGLESON, CHAS. F. MEBUS, S. M. SWAAB, HENRY HESS, J. M. DODGE.

Publication—M. E. HIBBS, J. E. GIBSON, RICHARD GILPIN, G. W. HYDE.

Library—B. A. HALDEMAN, H. C. BERRY, W. C. FURBER, F. N. MORTON, A. L. MAGITLON.

Publicity—J. R. BAILEY, D. R. YARNALL, F. K. WORLEY, G. T. GWILLIAM, H. B. ALLEN.

Advertising—M. E. HIBBS, J. E. GIBSON, RICHARD GILPIN, G. W. HYDE.

MEETINGS

Annual Meeting—1st Saturday of February, at 8:15 P. M.

Stated Meetings—1st and 3d Saturdays of each month, at 8:15 P. M., except between the fourteenth days of June and September.

Business Meetings—When required by the By-Laws, when ordered by the President or Board of Directors, or on the written request of twenty-five Voting Members of the Club.

The Board of Directors meets on or before the 3d Saturday of each month, except June, July and August.

SHALL we put your professional card in this space next time?

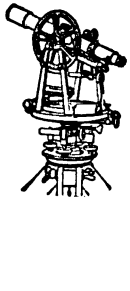
M. E. HIBBS
Chairman
Publication Committee
1317 Spruce St. Philadelphia, Pa.

WALSH PACKING CO.
PHILADELPHIA, PA.
MANUFACTURERS OF
"Walsh Metal Face Packing"
THE GREATEST HYDRAULIC PACKING ON THE MARKET
Walsh Combination Boiler Gaskets can be used from 10 to 30 times.

ALBRIGHT & MEBUS
CIVIL ENGINEERS
908 Land Title Building PHILADELPHIA
Sewerage, Sewage Disposal,
Municipal Improvements,
Examinations, Reports, Plans,
Construction Superintended

PMC
Pennsylvania Military College
CHESTER, PA.
Degrees in Civil Engineering, Chemistry, Arts. Thorough Preparatory Courses, Infantry, Artillery, Cavalry. *"A Military School of the highest order."*—U. S. WAR DEPT. Catalogues of **Col. C. E. HYATT, President.**

BERGER
TRANSITS and LEVELS



For State and Boundary line surveys, city work and all classes of work requiring the highest degree of accuracy.
Send for Catalogue
C. L. Berger & Sons
37 Williams St., BOSTON, MASS.

THE GENERAL CRUSHED STONE CO.
General Offices—EASTON, PA.

Quarries at	*Material*	*Daily Cap.*
North LeRoy, Genesee Co., N.Y.	Limestone	2000 tons
Akron, Erie Co., N. Y.	Limestone	1200 tons
Hendlers, Luzerne Co., Pa.	Quartzite	1500 tons
White Haven, Luzerne Co., Pa.	Sandstone	500 tons
Redington, Northampton Co., Pa.	Dolomite	1200 tons
Rock Hill, Bucks Co., Pa.	Trap	1200 tons
Glen Mills, Del. Co., Pa.	Trap	1500 tons

Philadelphia Office:
Franklin Bank Building

THE COCHRANE MULTIPORT

Interested in Back Pressure Valves?

THE COCHRANE MULTIPORT possesses one big advantage over all others—it is safer—absolutely safe. Instead of having one large disk it has several small ones—no chance of sticking. No weights to move either. It cannot be overloaded and it is fool-proof.

THE COCHRANE METERING HEATER is the latest addition to the Cochrane family. It meters your boiler feed water as well as heats it—all in one apparatus.

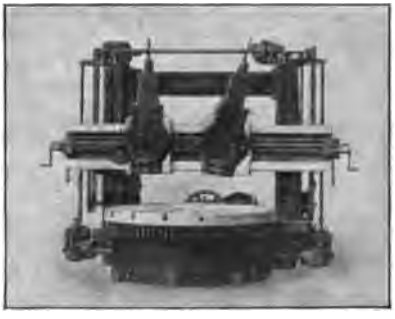
Engineering Booklet No. 11 tells about the valves and *No. 13* about the Metering Heater. Both belong in your file. See that they get there.

HARRISON SAFETY BOILER WORKS
3150 N. 17TH STREET. PHILADELPHIA, PA.

William Sellers & Co. Incorp. *Philadelphia*

LABOR SAVING MACHINE TOOLS

Boring & Turning Mills
Tool Grinders
Drill Grinders
Axle Lathes
Wheel Lathes



Drilling & Boring Machine
Planers
Slotters
Steam Hammers
Sand Mixers

CRANES—POWER TRANSMISSION—INJECTORS

THE DEFRAIN SAND COMPANY

BUILDING MATERIALS

BEACH AND BERKS STREETS

WHARVES { BERKS ST., DELAWARE RIVER / CHRISTIAN ST., SCHUYLKILL RIVER } PHILADELPHIA

DELIVERIES BY BARGE, RAIL OR TEAM

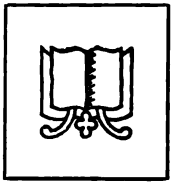
TO ADVERTISERS

The 1913 Directory of
THE ENGINEERS' CLUB of Philadelphia
WILL BE ISSUED JULY 31, 1913

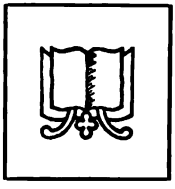
For space and rates address M. E. HIBBS
Chairman Publication Committee
or EDW. E. KRAUSS, Secretary
1317 SPRUCE STREET, PHILADELPHIA, PA.

The Intelligencer Printing Co.

LANCASTER, PENNSYLVANIA



MAKERS OF BOOKS
CATALOGUES
PERIODICALS



MONOTYPE AND LINOTYPE TYPESETTING MACHINES

Philadelphia Representative: { *ROLLAND M. HUNTER,*
1002 Real Estate Trust Building ::

ELEPHANT BRAND

ELEPHANT BRAND
DELTA
REG. U. S. PAT. OFF.
THE PHOSPHOR BRONZE SMELTING CO.
2200 WASHINGTON AVENUE, PHILADELPHIA, PA.
ELEPHANT BRAND "Phosphor-Bronze"
INGOTS, CASTINGS, WIRE, SHEETS, RODS, Etc.
—DELTA METAL—
IN BARS FOR FORGING AND FINISHED RODS
ORIGINAL AND SOLE MAKERS IN THE U. S.

PHOSPHOR BRONZE

ENGINEERING RECORD

Authoritative and exhaustive on all features of

MUNICIPAL ENGINEERING
BRIDGE AND STRUCTURAL ENGINEERING
MILL AND POWER ENGINEERING
RIVER AND HARBOR IMPROVEMENTS
RAILWAY LOCATION AND CONSTRUCTION, and the
DESIGN AND HANDLING OF THE PLANT FOR BUILDING WORKS CLASSIFIED UNDER THESE BRANCHES

Weekly: $3.00 a Year

239 WEST 39th STREET, - - - - NEW YORK
REAL ESTATE TRUST BUILDING, - - - PHILADELPHIA

Industrial Engineering

¶ The paper that tells you how to reduce the costs of manufacture. Deals with every phase of shop operation. It is the only recognized authority on Scientific Management. Edited by WILLIAM KENT, author of the Mechanical Engineers' Pocketbook.

Published Monthly by

The Technical Literature Co.

120 W. 32d Street **New York**

Organized in 1877

THE ENGINEERS' CLUB

OF PHILADELPHIA

Present House, 1317 Spruce Street

was Opened December, 1908

Club Meetings are held on the first and third Saturday evenings of each month, to which Engineers visiting in Philadelphia are invited.

The Proceedings of the Club are published Quarterly.

A first-class Restaurant is maintained in the House, and a number of ROOMS are available for the use of members and guests.

"Websterizing"

That's the term used by a friend to express the peculiar efficiency given a steam plant by the use of

WEBSTER STEAM APPLIANCES

It means either giving increase of power or producing the same power for less cost; it means heating the feed-water to the highest point by using only part of the exhaust; modulating the heat in any room at pleasure; and doing all this and more with the simplest outfit, at less cost than in any other way.

Write for booklet 29-G, and learn how to "Websterize."

WARREN WEBSTER & CO.

Camden, N. J.

Philadelphia Office—1105 Stephen Girard Building

ENGINEERING NEWS

THE LEADER IN

Quality of Technical Matter Published. Advance News of Construction. Average Weekly Paid Circulation. Quality and Quantity of Advertising. Weekly Proposal Advertising. Weekly For Sale and Want Advertising.

Published Every Thursday $5.00 a Year

$2.50 for Six Months
Trial Subscription, Ten Weeks for $1.00

WRITE FOR FREE SAMPLE COPY

THE ENGINEERING NEWS BOOK DEPARTMENT publishes a number of Standard Technical Books and Specifications, and is also prepared to supply promptly, on receipt of price, any books of a technical or general nature other than those of its own publication.

Send for Catalogue

The Engineering News Publishing Company

223 BROADWAY, NEW YORK

Business Established 1826

RICHARD G. WOOD, President

J. R. JONES, Vice-President and Treasurer

WM. W. LUKENS, Secretary and Asst. Treasurer

Alan Wood Iron and Steel Company

MANUFACTURERS OF

Basic Open Hearth Steel Billets, Blooms, Slabs, Black and Galvanized Iron and Steel Sheets and Plates

SPECIALTIES:

Locomotive Jacket, Blue Annealed, Bath Boiler, Swede and Norway Sheets, Gas Holder, Corrugated, Best Bloom, A. W. Clean, M. F., Cold Rolled Sheets, Pickled and Cold Rolled Sheets, Electrical Iron and Steel, Best Last, Water Pipe and Light Plates.

"A. W. DIAMOND" and "A. W. RIBBED" PATTERN ROLLED STEEL FLOOR PLATES

Sizes Furnished on Application.

Morris Building **Philadelphia**

THE ENGINEERING MAGAZINE

ENGINEERS, SUPERINTENDENTS & MANAGERS

THE ENGINEERING MAGAZINE publishes the best original articles by the highest authorities on all phases of current engineering progress.

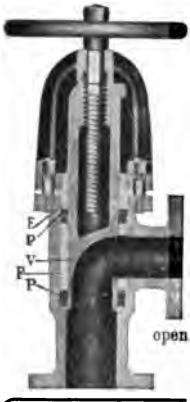
Additional and *exclusive* features are: A Review and Topical Index to the current contents of nearly two hundred engineering and industrial journals; Current Record of New Technical Books; Industrial News; latest Improved Machinery and new Trade Literature.

Ask for sample copy and descriptive circular.

THE
ENGINEERING
MAGAZINE

140-142 Nassau St., New York

81% Re-orders



DESCRIPTION---In closing Valve, shoulder on Plunger V engages the loose follower gland F, compressing packing P above and below the port, making an absolutely tight valve.

Proves the Success of the

SIMPLEX Seatless Blow-Off Valve

¶ Test one or more right in your own Plant, for

60 DAYS' FREE TRIAL

or let us send you complete description and monthly magazine, "The Blow-Off"

WRITE US NOW

It Takes Only Five Minutes to Stop the Worst Pipe Leak With a

SIMPLEX

Pipe - Joint Clamp

and it'll save you hours spent in taking down a pipe line—save you trouble and expense—because it makes a permanently tight joint.

¶ Let us send you a Simplex on 30 days' free trial.

Write To-Day For Booklet

Yarnall-Waring Co.

Chestnut Hill
Philadelphia

DESCRIPTION--1. Square packing ring, forced against leaky joint. 2. Inside ring, forced against packing 1 by screws 4. 3. Outside ring bolted around pipe by bolts 6, secured by set screws 5, prevents slipping when adjusting screws 4.

Success!

The safest gauge of value is success.

This is an old adage, and a true one.

Particularly does it apply to the valve business.

For, unless compared closely, one make of valve looks very much like all the others.

So the valve *user* is too apt to be misled, unless he is guided by some safer guage than *appearance*.

The appearance of

Nelson Valves

sells lots of them.

Close comparison of NELSON VALVES right along side of others sells even *more* of them.

But what really sells *most* of them is their success; success in real and hard service.

And this success in *real service* is the only thing that builds up institutions like the

Nelson Valve Company

This is the kind of success which raised the NELSON COMPANY in twenty years from just a small plant to a plant which is conceded by experts to be the finest in the United States.

This is the success which is your safest gauge of value, and which makes the NELSON your safest valve investment.

Will you take the time right now to acquaint yourself with a valve proposition which is good enough to accomplish all this?

It will take just a minute to drop us a line, and it will pay you.

Nelson Valve Company
Chestnut Hill :: Philadelphia

JUST send 25 cents for four months' trial subscription

THE INDUSTRIAL MAGAZINE

203 Blackstone Building
Cleveland, O.

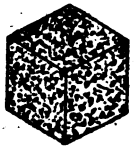
Vulcanite
Portland Cement

TRADE MARK
VULCANITE PORTLAND CEMENT
V
VULCANITE PORTLAND CEMENT CO.
REG. U.S. PAT. OFFICE

The Brand with a Reputation

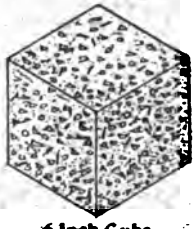
Land Title Building
Philadelphia

PHOENIX PORTLAND CEMENT



4 Inch Cube
Broke at
68,350 Pounds

THESE blocks were cut from the East Abutment of the P. B. & W. R. R. Bridge at Perryville, Md. The Concrete was Machine mixed in the proportions of 1-2-5 and placed in the Abutment on January 18, 1905, and was made of Phoenix Portland Cement, Wilmington Sand and Port Deposit Granite. These blocks were tested at Columbia University, April 22, 1905.



6 Inch Cube
Stood 100,000 Pounds
without a sign of a
crack—the full capacity of the machine

McMULLEN & McDERMOTT
Park Row Building, New York, Contractors

T. KENNARD THOMSON
Engineer for Contractors

WM. G. HARTRANFT CEMENT CO.

SOLE SELLING AGENT

Real Estate Trust Building — Philadelphia, Penna.

DEXTER PORTLAND CEMENT

EVERY BAG ALIKE

UNEQUALLED
FOR REINFORCED
CONCRETE

DEXTER PORTLAND CEMENT CO.
FINENESS STRENGTH
TRADE MARK
PORTLAND
UNIFORMITY
NAZARETH PA.

THE HIGHEST
STANDARD
ATTAINABLE

SOLE AGENTS

SAMUEL H. FRENCH & COMPANY

York Ave., Fourth and Callowhill Sts., — Philadelphia, U. S. A.

Established 1844